The evaluation and improvement of a Sustainability Index for Integrated Urban Water Management in South African Cities

Case study applications:
East London and Port Elizabeth

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DECLARATION

I, Charlene Mureverwi, know the meaning of plagiarism and declare that all the work in the document, save for that which is properly acknowledged, is my own.

Signed: ____________________________ Date: ____________

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Abstract

Water is not only essential for maintaining life; it is a key component of sustainable social and economic development having links to, *inter alia*, health, “sense of place”, food production and industrial growth. Although progress has been made with regard to water supply, it is estimated that there are still 2.4 million people in South Africa without access to adequate water and sanitation services as defined by the United Nations (Statistics South Africa, 2008). It is possible that the failure in service provision can partly be attributed to a lack of an integrated approach with regard to the various aspects of urban water management. Stoeckigt (2006) and De Carvalho (2007) used a systems approach to develop a composite Sustainability Index (SI) which, by addressing five components of sustainability (environmental, social, economic, political and institutional), attempts to give a measure of the potential for sustainability in the context of integrated urban water management. This thesis describes an evaluation and modification of this Sustainability Index.

The literature presented in this research examines Integrated Urban Water Management (IUWM) and sustainability indicators. A particular focus was given to service provision in South African cities and the various aspects of the urban water cycle. This thesis set out to explore the possibilities for the improvement of the SI to guide the efficient delivery of services and appropriate description of human impacts on the environment. From the literature reviewed, it was concluded that the success of IUWM requires an interdisciplinary approach with strong political and institutional backing.

The evaluation and modification of the SI was guided by knowledge gained from a review of the literature and through experience gained from applying the SI to two case study areas. Two South African cities, East London and Port Elizabeth were selected as case studies to test the applicability and validity of the original and revised index. In the evaluation of the SI, data accessibility and transparency in the method were used to determine the effectiveness of the index. This was done with the objective of improving the SI and ultimately promoting sustainability performance in the management of urban water systems. East London and Port Elizabeth obtained overall SI scores of 56% and 60% respectively. East London and Port Elizabeth both performed best in the political component receiving scores of 83% and 93% respectively. On the other hand, both cities score lowest on the environmental component of the SI. This indicated a need for more stringent environmental monitoring. In applying the SI to the case study areas, a number of priority areas, which need to be addressed by the respective municipalities were highlighted. The overall SI performance for both cities shows relatively slow progress towards sustainability with both East London and Port Elizabeth needing to improve their urban water management. Results of the analysis demonstrated that the revised index can highlight areas for improvement and ultimately guide more appropriate policies for better service delivery and improved resource management.

Acronyms

CSD:	Commision on Sustainable Development
DEAT:	Department of Environmental Affairs and Tourism
DWAF:	Department of Water Affairs and Forestry
DWEA:	Department of Water and Environmental Affairs (formerly DWAF)
EF:	Ecological Footprint
EL:	East London
ESI:	Environmental Sustainability Index
FBW:	Free Basic Water
GDP:	Growth Domestic Product
HDI:	Human Development Index
HIV/AIDS:	Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome
IUCN:	International Union for the Conservation of Nature and Natural Resources (World Conservation Union)
IUWM:	Integrated Urban Water Management
IWRM:	Integrated Water Resource Management
LCA:	Life Cycle Assessment
MDGs:	Millennium Development Goals
NGOs:	Non-Governmental Organisations
NRF:	National Research Fund of South Africa
NRW:	Non-Revenue Water
OECD:	Organisation for Economic Cooperation and Development
PE:	Port Elizabeth
SADC:	Southern African Development Community
SACN:	South African Cities Network
SI:	Sustainability Index
SUDS:	Sustainable Urban Drainage Systems
UFW:	Unaccounted For Water
UN:	United Nations
UN:	United Nations Development Programme
UNEP:	United Nations Environment Programme
UWM:	Urban Water Management
WB:	World Bank
WCED:	World Commission on Environment and Development
WHO:	World Health Organisation
WRC:	Water Research Commission
WSSD:	World Summit on Sustainable Development

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1. Introduction

1.1 Background

"Water is essential for all dimensions of life. Over the past few decades, use of water has increased, and in many places, water availability is falling to crisis levels. More than eighty countries, with forty percent of the world's population, are already facing water shortages, while by year 2020 the world's population will double (World Bank Institute, 1999). The costs of water infrastructure have risen dramatically. The quality of water in rivers and underground has deteriorated, due to pollution by waste and contaminants from cities, industry and agriculture. Ecosystems are being destroyed, sometimes permanently. Over one billion people lack safe water, and three billion lack sanitation; eighty per cent of infectious diseases are waterborne, killing millions of children each year." (World Bank Institute, 1999)

The increase in the size of the human population in the past few decades has been unprecedented, particularly in less developed countries where the total population rose from 1.7 billion to 4.7 billion between 1950 and 1998 (World Bank Institute, 1999). This population growth has negatively impacted the Earth's resources and natural systems as more people rely on the environment for life. In particular, the world's water resources have become increasingly stressed with more than 1 billion people having little or no choice but to use potentially harmful sources of water (UNICEF & WHO, 2004). The combination of safe drinking water and hygienic sanitation facilities is a precondition for sustainable development and is also central to human rights and personal dignity of every person on earth (UNDP, 2005). This realization prompted countries around the world to commit to achieving the Millennium Development Goals (MDGs) as set by the United Nations (United Nations, 2006).

Progress towards achieving the MDGs in sub-Saharan Africa, particularly in respect of access to water (target 7C), has been relatively good with the percentage of households with a water source within 200m of their household increasing from 49% to 58% between 1990 and 2002. However, this falls far short of the progress needed to achieve the MDG target of 75% by 2015 (UNICEF &WHO, 2004). Obstacles to accelerating the rate of progress in this region include conflict and political instability in countries such as Mozambique and Zimbabwe (UNDP, 2005). Furthermore, the low priority being given to water supply and infrastructure maintenance has resulted in the breakdown of water supply systems in these countries. Among the approaches shown to be effective in speeding up progress in the region are decentralizing responsibility and ownership and providing a choice of service levels to communities based on their ability and willingness to pay (UNICEF &WHO, 2004).

The South African Government has made some progress in reducing the water and sanitation backlogs in this country. Nonetheless, there are major problems with service delivery, mostly in the larger towns and cities where population growth is faster than the rate of service delivery. The assumption in this thesis is that one of the key issues contributing to the government not being able to meet the service provision needs of its citizens is its apparent inability to consider the problem as a whole. The long-term sustainability of the urban water cycle (principally; water supply, sanitation, drainage, wastewater treatment, groundwater and urban rivers) depends on a clear understanding of the links between each of the various elements. This research suggests that if decision-makers had a better understanding of the linkages, they would be better able to provide solutions to the service delivery crisis.

The lack of clear-cut solutions in areas such as service delivery has highlighted a need for tools that could help in monitoring the progress achieved by governments towards sustainable development. The development of such a tool is the focus of this research. This thesis forms part of the sustainable urban water management research thrust that is being carried out by the Urban Water Management (UWM) group at University of Cape Town (UCT). This research seeks to investigate the development of a Sustainability Index (SI) for the measurement of the long-term sustainability of urban water systems (including water supply, sanitation and drainage) focusing on cities of South Africa. Previous work on the SI has been done by Stoeckigt (2006), De Carvalho (2007), Hotchkiss (2008) and Makgalemele (2008). The preliminary SI was developed and tested on the following cities; Maputo (Mozambique), Hermanus (Western Cape, SA), Franschhoek (Western Cape, SA) and Stellenbosch (Western Cape, SA).

It is hoped that this SI will identify the key components that need to be addressed by the appropriate authorities with regard to urban water management. The SI will hopefully aid decision-makers in their assessment of the best possible solutions for the provision of sustainable water services. In other words, it is anticipated that the index will serve as an advocacy tool to promote sustainable management of water systems. The research is supported by the National Research Foundation (NRF) and the African Center for Cities (ACC) network of researchers. ACC is an organisation based at UCT that seeks to "facilitate a critical urban research and policy discourse for the promotion of sustainable urban development in the South."

1.2 Aim of research

The aim of the research was to improve the SI developed by De Carvalho (2007). This was achieved by optimising various aspects of the index such as the selection of indicators and the weighting system. The robustness of the SI was assessed with the aid of data from two case study areas. Ultimately, it is hoped that the SI will be suitable for use by municipal structures as a tool for monitoring progress towards integrated water management, thereby promoting sustainable water service delivery in South Africa.

1.3 Thesis layout

This thesis consists of seven chapters. The Introduction has provided a background to the research by explaining some of the issues currently being faced by developing countries. The chapter also outlines the aims of the research, both as an individual piece of work and in view of the broader research initiative taken at the University of Cape Town. Chapter 2 presents the findings of the literature review and explores in greater depth the general understanding of the concepts of sustainability and IUWM and the means of monitoring and achieving them. Chapter 3 describes the methods adopted for modifying and evaluating the index and the methods explored for data analysis. A brief description of the case study selection is included. Chapter 4 provides an in-depth assessment of the SI as developed by De Carvalho (2007). The chapter also explains how the SI was modified. Chapter 5 begins by providing a brief description on the Eastern Cape Province, which is where both case study areas are located. The chapter then introduces the two case studies, East London and Port Elizabeth, describing the cities in terms of their spatial, social, economic and biophysical contexts as well as the institutional structures that govern them. Chapter 6 presents a discussion of the results obtained from the indicator applications and modification. A comparison of the SI as developed by De Carvalho (2007) and the revised SI follows. The chapter also highlights the limitations and problems encountered during the research process. Finally, Chapter 7 recapitulates the findings of the study and makes recommendations firstly for the improvement of sustainability performance in the cities of East London and Port Elizabeth and secondly for the further improvement of the SI.

2. Literature Review

This literature review provides an overview of the main themes and concepts explored in this research. The chapter begins by examining the notion of sustainable development. Thereafter, particular focus is given to service provision in South Africa and how sustainable development principles should guide progress in the country. Integrated Water Resource Management (IWRM) is then described as an emerging approach for sustainable water management. The various aspects of water services management are explored. Subsequently, literature on assessing progress toward sustainable development and theory on sustainability indicators is studied. Particular attention is given to the development and application of the Sustainability Index (SI) for urban water management. The literature review concludes with a summary of the main issues and gaps in the literature.

2.1 Understanding sustainability and sustainable development

2.1.1 Sustainability concepts

Sustainability explores the relationship between economic development, environmental quality and social equity (Rogers *et al.*, 2006). This concept has been evolving since 1972, when the international community first explored the connection between quality of life and environmental quality at the United Nations Conference on the Human Environment in Stockholm (UN, 2006). The term 'sustainable development' only came into the public arena in 1980 when the International Union for the Conservation of Nature and Natural Resources (IUCN) presented the 'World Conservation Strategy' (IUCN, 1980). It was aimed at achieving sustainable development through the conservation of living resources. Nonetheless, its focus was rather limited, primarily addressing ecological sustainability as opposed to linking sustainability to wider social and economic issues (Baker, 2006).

It was not until 1987 when the World Commission on Environment and Development (WCED), also known as the Bruntland Commission, published its report, 'Our Common Future', that the links between the social, economic and ecological dimensions of development were explicitly addressed (WCED, 1987). The concept was further consolidated at a UN Conference on Environment and Development held in Rio de Janeiro in 1992, and was strongly asserted at the World Summit on Sustainable Development (WSDP) held in 2002 in Johannesburg (UN, 2006). Today, sustainability reports of cities are an example of how international debates on sustainability are influencing local policy decisions. Attempts at quantifying the sustainability of cities are the first step in understanding the problems associated with unprecedented population growth and finite resources (City of Cape Town, 2005). These reports hope to go beyond awareness creation, to bring about informed responses from all sectors of society.

2.1.2 Key principles and definitions

A commonly cited definition of sustainable development states that:

"*Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (WCED, 1987).

This definition establishes the need for integrated decision-making that is capable of balancing people's economic and social needs with the regenerative capacity of the natural environment (Mebratu, 1998). Sustainable development is a "*dynamic process of change in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional change are made consistent with future as well as present needs*" (Rogers *et al.*, 2006). According to the Brundtland Commission, sustainable development relies on the political will of the governments involved as critical economic, environmental and social decisions have to be made (Rogers *et al.*, 2006).

Development is defined by the United Nations as the "*promotion of social progress and better standards of living in larger freedom*" (UN, 2006). Goodland & Daly (1996) note that there is a difference between development and growth, where to grow is to increase in size by assimilation; while to develop is to expand, bring out capabilities or to advance from a lower to a higher state. Sustainability is based on the recognition that when resources are consumed faster than they are produced or renewed, the resource is depleted and eventually used up. In a sustainable world, society's demand on nature is in balance with nature's capacity to meet that demand. When humanity's ecological resource demands exceed what nature can continually supply, the human population moves into what is termed 'ecological overshoot' (World Resources, 2000).

Environmental sustainability implies that development is carried out within the absorptive and regenerative capacities of its biophysical environment. This means wastes are kept within assimilative capacities, harvesting is within regenerative capacities of renewable resources, and non-renewable resources are not depleted at a faster rate than that at which substitutes are developed (Goodland & Daly, 1996). An environmentally sustainable city is one "*which meets its present and future human development goals without growth in throughput of matters and energy beyond the regenerative and absorptive capacities of its local, national or international surroundings*" (Gasson, 2000).

Economic sustainability is often defined to be 'the maintenance of capital', where the capital is found in four types, namely; human, natural, social and human-made (Goodland & Daly, 1996). Common use of the term 'economic sustainability' is however often neglectful of social and natural capital. Concepts such as poverty and freedom (social capital) and natural resources are difficult to quantify, much less monetise. Although some progress has been made in terms of incorporating these categories in economic considerations, the three categories of sustainable development; economic, social and environmental, are often disaggregated.

Social sustainability has been described as the maintenance and replenishment of 'moral capital', sustained though the "*maintenance of shared values and equal rights and by community,* *religious and cultural interactions*" (Goodland & Daly, 1996). As a whole, sustainable development is the "*approach or means employed to achieve growth and development (meet current needs) in a manner that is responsive to the earth's capacity to regenerate resources and absorb wastes, being conscious of the needs of future generations*" (Goodland & Daly, 1996).

There are three levels of sustainability according to Sutton (2000). Table 2.1 illustrates the various levels, i.e., survival sustainability, maintenance sustainability and improving quality of life. Survival refers to the achievement of basic sustainability, and maintenance sustainability refers to the preservation of the generally expected quality of life. The third level goes beyond notions of expected quality of life to propose a higher standard of living. Table 2.1 illustrates these three levels.

Table 2.1 Dimensions and levels of sustainability (Sutton, 2000)

	Ecological	**Social**	**Economic**
Level 1: Survival Sustainability	Protection of life support systems Prevention of species extinction	Capacity to solve serious problems	Subsistence
Level 2: Managing quality of life	Maintenance of decent environmental quality	Maintenance of decent social quality i.e. vibrant community life	Maintenance of decent standard of living
Level 3: Improving quality of life	Improving environmental quality	Improving social quality	Improving standard of living

The research being undertaken in this thesis focuses on how cities manage their water taking into account the various systems of sustainability. The three systems most recognised when it comes to sustainability are the environmental, social and economic systems, commonly referred to as the triple bottom line as shown in Figure 2.1 (Sutton, 2000). A different model of the interconnectedness of such systems within the broader ecosystem is highlighted in Figure 2.2. These systems are intricately interconnected and often the change of one system dramatically impacts others.

Sustainable development is dependent on the balance of all three aspects; social development, economic growth and environmental protection. Of all three, environmental protection is often the least acknowledged and at times the most limiting factor to the growth of cities. When trying to achieve sustainable development it is important to know how current development approaches are impacting the environment that supports people. These impacts include not only physical consequences for the environment, but also associated economic and social consequences. It is therefore useful to assess economic, environmental and social development by the use of simple and reliable indicators which highlight areas where improvement is needed (Rogers *et al.*, 2006). An in-depth discussion on measuring sustainability takes place later on in the chapter.

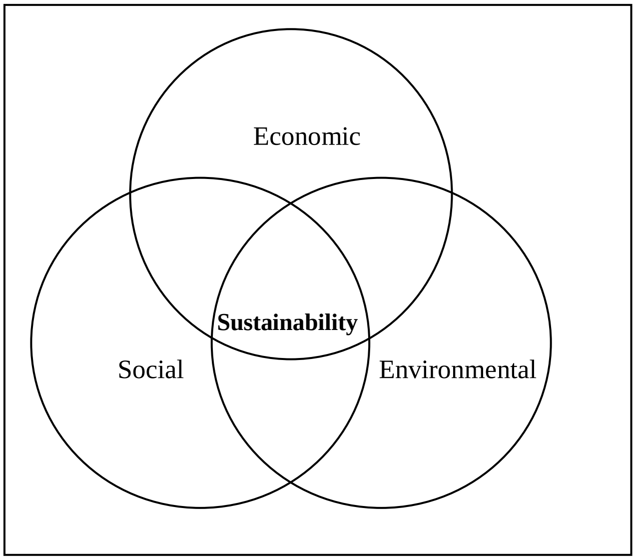

Figure 2.1: The triple bottom line concept (Sutton, 2000)

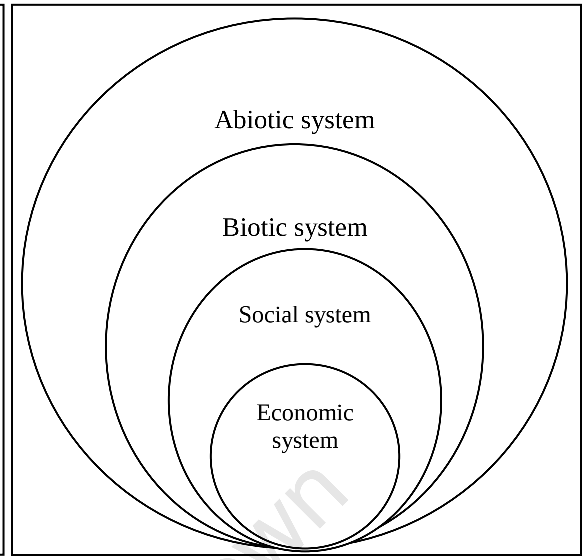

Figure 2.2: Interconnected systems (Mebratu, 1998)

2.1.3 International engagement with sustainable development

Various international meetings and agreements reflect the growing movement world-wide to act on and positively change current development trends. These agreements, while not often legally enforceable, aim to create the necessary awareness and commitment amongst political powers. There is criticism that, although they are accepted in the developing world, these sustainable development agreements are far from being implemented (Baker, 2006). Nonetheless, it is important to note that the consensus reached at meetings such as the Rio Earth Summit, create essential avenues for thinking of, and acting on, sustainable development.

2.1.3.1 The Rio Earth Summit

In 1992, the UN called for the convening of the UN Conference on the Environment and Development in Rio de Janeiro, later known as the Rio Earth Summit (UNEP, 2005). The Rio Earth Summit focused on two key issues: first, the link between environment and development; and second, the practical issues surrounding the promotion of sustainable development. Agreements reached at the Rio Earth Summit include The Rio Declaration on Environment and Development, and Agenda 21. The Rio Declaration presents 27 principles of sustainable development which encourage good governance and environmental conservation. Agenda 21 calls for the creation of global partnerships and acknowledges the need for equitable and integrative development principles (Baker, 2006).

The Rio Earth Summit led to the establishment of an institution called the Commission on Sustainable Development (CSD), whose primary role is to monitor progress on the agreements reached at Rio. In 1995 the CSD approved the Programme of Work in Indicators of Sustainable

Development and called upon the organizations of the UN system, intergovernmental agencies and NGOs to implement the key elements of the work programme. The main objective of the CSD Work Programme was to make indicators of sustainable development accessible to decision-makers at a national level by defining them, elucidating their methodologies and providing training (UN, 2001). The CSD Work Programme was conducted between 1995 and 2000, and the indicators developed through this programme are now used in national reports to facilitate decision making.

The CSD has been charged with establishing sustainable development indicators. This mandate has made the CSD subject to considerable criticism as being a slow operating organisation. Several arguments made in its defence include the fact that the organisation has to address a complex array of issues and tread a politically delicate path whilst trying to fulfil the high expectations placed upon it (Baker, 2006). Despite these difficulties, the CSD has been able to position itself at the centre of all the worldwide follow-ups to the Rio Summit (Baker, 2006). This has enabled the organisation to monitor governments' commitment to agreements reached at these meetings. However, the usefulness of this global reporting is dependent upon the development of an agreed-upon set of indicators for measuring progress. Indicators developed by the CSD help to measure progress towards sustainable development (UN, 2001).

2.1.3.2 Millennium Development Goals (MDGs)

The Millennium Development Goals were adopted by the majority of governments world-wide during the September 2000 United Nations Millennium Summit in a concerted and cooperative effort to address the main challenges of development by specified target dates. The eight goals comprise 18 quantifiable targets which are further disaggregated into 48 indicators, to provide a framework and guide for development initiatives (UN, 2006). The eight goals are as follows:

Goal 1: Eradicate poverty and hunger

Goal 2: Achieve universal primary education

Goal 3: Promote gender equality and empower women

Goal 4: Reduce child mortality

Goal 5: Improve maternal health

Goal 6: Combat HIV/AIDS, malaria and other diseases

Goal 7: Ensure environmental sustainability

Goal 8: Develop a Global Partnership for Development

Specific targets under Goal 7 express a need to integrate principles of sustainable development into policies and programmes; the need to halve the number of people without access to safe drinking water by 2015, and the need to upgrade and considerably improve the lives of 100 million slum dwellers by 2020 (UN, 2006). Service delivery is seen as one of the first steps towards achieving sustainable development (UNDP, 2005). The study areas used in this research are both South

African cities. Therefore, a closer look at the status of service delivery in South Africa is necessary. The following section discusses the progress made by South Africa in improving service delivery and highlights the challenges faced by the country.

2.2 Service provision in South Africa

2.2.1 The Apartheid legacy

When the African National Congress (ANC) came into power in 1994 policies were developed which aimed to deal with the inequality caused by the injustices of apartheid. The effects of apartheid history are still evident in South African cities through residential segregation and high levels of inequality in access to public services. A primary objective of the African National Congress (ANC) since the first democratic elections in 1994 has been to redress the impacts of apartheid through a more equitable distribution of public services (Smith & Hanson, 2003). During the past decade, local government in South Africa has given a distinctly new status and role towards building democracy and promoting social development, through a number of Acts and Bills, changes that were introduced through privatization and the implementation of affirmative action have had far-reaching consequences which have being debatably helpful in assisting previously disadvantaged communities (Smith & Hanson 2003).

Among the many new laws that have been enacted, the Municipal Services Act of 1998, (DWAF, 2004) has introduced the demarcation of new municipal boundaries and the formation of mega-cities, district councils and local councils. In addition, the Municipal Systems Act of 2000, which introduced Integrated Development Plans (IDPs), has privatized municipal service delivery and legislated the implementation of performance management systems (Ramba & de Souza, 2008). South Africa, like many developing countries, faces significant challenges in the sustainable provision of adequate and safe water services, notwithstanding the good legislative framework. Despite considerable success in addressing water services backlogs, many Water Service Authorities (WSAs) continue to have inadequate water and effluent treatment and associated water quality management practices in place (Ramba & de Souza, 2008).

2.2.2 South Africa's policy environment and institutional structures

Social equity and the right to a healthy environment are central to South Africa's Constitution. Section 24 of the Constitution states that "*Everyone has the right to an environment that is not harmful to their health or wellbeing; and to have the environment protected for the benefit of present and future generations through reasonable legislative and other measures that prevent pollution and ecological degradation, promote conservation and secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development*" (Republic of South Africa, 1996).

The National Water Act (No. 36 of 1998) has placed sustainability and equity as the two guiding principles for the management of water resources (DWAF, 2002). It introduces the idea of reaching a balance between sustainability goals on the one hand and social development goals on the other, a concept that is also central to the Environmental Management Act (No. 107 of 1998) which stresses the importance of environmental, social and economic sustainability in all areas of planning, implementation and decision-making (DWAF, 2002). Supporting legislation such as the Water Services Act (Act 108 of 1997) and the Strategic Framework for Water Services (DWAF, 2003) guide progress at all levels of government, particularly at the implementation level of municipalities (DWAF, 2002).

Water governance in South Africa takes place on various levels. The Department of Water and Environmental Affairs (DWEA), previously known as Department of Water Affairs and Forestry (DWAF), is the custodian of South Africa's water resources and is responsible for planning and decision-making at a national and international level. DWEA is not responsible for implementing and operating water services, but rather oversees and regulates the water services providers. Catchment management agencies (CMAs) are responsible for water resource management at a catchment level and help to ensure efficient water allocation. Much of the management of water resources in terms of providing water services is undertaken by Water Services Authorities (WSA), usually at a local municipality level, which in turn is guided by the Water Services Act (No. 108 of 1997). It is the Water Services Authority's constitutional duty to secure water sources from DWEA or the relevant CMA, and to ensure that the public within their jurisdiction have access to the necessary water supply services and that wastewater is treated to national quality standards and safely discharged (DWAF, 2003).

Although South Africa has good policies when it comes to sustainability and integrated water management, many authorities are struggling to fulfil the requirements written into the Acts and supporting guidelines. Another issue which appears to be lacking in water governance in South Africa is the understanding of the concept of sustainability. Water authorities have been inundated with development targets without prior thought to technical feasibility, and sustainability has taken on a very narrow definition with a primary focus on improving service provision for the poor. Environmental compromises are being made to achieve the pressing societal needs of today and it seems that very little thought is being given to the needs of future generations (SACN, 2006).

2.2.3 Status of service delivery in South African cities

There are major problems with the provision of services in urban areas where population growth, mainly resulting from the migration of people into major city centres, outstrips the rate of service delivery. Recent figures show that 12.3% of South Africa's urban population is still without access to basic water supply whilst 23.1% of the country's urban population is without access to basic sanitation (DWAF, 2004). In South Africa, basic service levels for water are defined as a minimum quantity of 25 litres of potable water per person per day within 200 metres of a household, not interrupted for more than 7 days in any year, and a minimum flow of 10 litres per minute for communal water points (DWAF, 2004). This is a substantially higher standard than the basic services defined by the Millennium Development Goals of 20 litres of potable water per person per day within 1 000 metres of a household (UN, 2006).

Since 1994, nearly all resources available for municipal infrastructure have been redirected to the previously disadvantaged areas where undesirably low levels of access to services exist. One of the government's priorities in alleviating poverty is to provide access to services to all the country's citizens. The provision of basic housing has being one area that the government has invested in. The Reconstruction and Development Property (RDP) policy promotes the development of cost-effective and simple methods to build low cost housing in South Africa. RDP housing is very basic and consists of one bedroom, a sitting room, kitchen and toilet and is mainly provided for the poor and disadvantaged, however corruption in the distribution of these houses is hampering its success. Nonetheless, between April 1994 and March 2005, approximately 2.4 million housing subsidies were approved and 1.75 million housing units were built during the same period.

In 2007, 74.4% of households in South Africa had access to piped water within 200 meters of their dwelling (Statistics SA, 2008). Unfortunately, access to services alone does not provide the complete picture of service delivery. In numerous South African cities the concerted drive for service expansion is being done at the expense of existing services requiring urgent maintenance or refurbishment. Several municipalities simply do not have sufficient resources for both service expansion and infrastructure maintenance. Often maintenance of existing services is neglected which begs the question that if municipalities cannot find enough resources to maintain existing infrastructure, how will they be able to maintain systems with all the additions (Smith & Hanson, 2003).

Affordability is an important factor to consider in the service delivery parcel. First it is necessary to determine the extent of cost, then determine how best to distribute the cost amongst users, or alternatively, whether the service provider could absorb the cost. The actual provision of infrastructure is clearly also only another part of this parcel, and how effectively the infrastructure functions, another. Therefore, the quality of the infrastructure, the effective functioning of the service, the affordability of the service, and access to the service should all be measured when service delivery is evaluated (Kluge, 2007).

Successful water delivery and provision are central to poverty alleviation in South Africa. Within the context of the Millennium Development Goals (MDGs), the provision of adequate water supply is linked to the goal of ensuring environmental sustainability. Despite landmark pieces of legislation such as the National Water Act and the Environmental Management Act, both of which are based on the principles of sustainable development, authorities are still struggling to implement the requirements of these Acts in respect of service delivery (CSIR, 2007).

The following points highlight the way forward for South Africa to meet the MDG water and sanitation targets (UNICEF & WHO, 2004):

- Upscale all efforts to decentralize water supply and sanitation services to appropriate administrative levels and create water governance at all levels of management that is transparent, open, accountable, gender-responsive, participatory, communicative, effective, and socially, culturally, and environmentally acceptable

- Invest adequately in building gender-balanced institutional, technical and managerial capacities at all levels of the professional ladder, from artisans to planners and designers
- Give prominence to sanitation, including extensive and intensive health and hygiene education at the community level
- Take appropriate measures to protect groundwater and surface water quality from pollution
- Ensure the development of appropriate monitoring and evaluation mechanisms for water supply and sanitation at the local and national levels, to reinforce the global WHO UNICEF joint monitoring program.

It is important for cities to plan for the future in order for the benefits of IUWM to be experienced. For South African cities, the following frameworks are in place to guide sustainable development and the maintenance of service delivery:

- Integrated Development Plans (IDPs) - the goal of IDPs is to bring about prosperous cities that deliver services in an equitable and effective manner though well-governed administrations.
- Water Services Development Plans (WSDPs) – are plans which explain ways in which the city aims to ‘provide equitable, sustainable, people-centered, affordable and credible water services to all’ (DWAF, 2004).

The benefits of improved service delivery are clear but the challenges of managing water systems in a sustainable manner still remain. The following section describes various integrated approaches to water management when dealing with limited water resources and the complex interactions between people and the natural and constructed systems within which they live.

2.3 Integrated Water Resource Management (IWRM) and Integrated Urban Water Management (IUWM)

2.3.1 The concepts of IWRM and IUWM

In South Africa, urban water management has water supply, wastewater, stormwater and groundwater as largely separate elements, with the planning, installing and operating of these components of the urban water cycle making little reference to one another. The reality however, is that these systems have significant interactions, for example as an urban area grows, the carrying capacity of the water infrastructure such as a sewer system can be exceeded leading to problems such as uncontrolled overflows of poor quality water into rivers. IWRM takes a comprehensive approach to water services by viewing the various components as an integrated system (Fletcher & Deletic, 2008).

The basis for the discussion around IWRM was laid at the International Conference on Water and the Environment (ICWE) in 1992 in Dublin where the so-called 'Dublin Principles' were formulated (Solanes & Gonzalez-Villarreal, 1999):

- Freshwater is a finite and valuable resource, essential for sustaining life, development and the environment
- Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels
- Women play a central part in the provision, management and safeguarding of water
- Water has an economic value in all its competing users and should be recognized as an economic commodity.

IWRM is seen as a "problem-solving approach to address key water challenges in ways that are economically efficient, socially equitable and environmentally sustainable" (Kluge, 2007). An IWRM approach explicitly recognizes the complex sets of interdependency relationships which exist within and between human and environmental systems (Rees, 2006). IWRM is not an objective in its own right but a means to increase the benefits derived not only from the scarce water resource itself but also from the equally scarce financial and human capital resources needed to convert the water resources into useable products and services (Rees, 2006).

In order for countries to address challenges concerning water management, they need to consider the numerous and complex links between activities that influence and are influenced by the way in which the resource is managed. At the Mexico 4th World Water Forum in 2006 it was agreed that the manner in which countries deal with their water management challenges depends on their situation and development priorities (World Water Council, 2006). Today, many countries have found that the process of creating an IWRM plan and water efficiency strategy, as called for in the Johannesburg Plan of Implementation in 2002, is an opportunity to take a coherent approach to improving how they develop, manage and use water resources to further sustainable development goals and meet development challenges (World Summit on Sustainable Development, 2002).

Integrated Urban Water Management (IUWM) is a component of IWRM and addresses the imposition of society on the natural water cycle in the urban context as well as the exploration of avenues for improved service delivery through appropriate management and concerted action. It has been described by UNEP (2005) as "*the practice of managing freshwater, wastewater and stormwater as links within the resource management structure, using an urban area as the unit of management*". IUWM reconciles social equity with economic efficiency as well as environmental sustainability, and recognizes that robust systems are needed to encourage structured decision-making in this regard. IUWM also takes into account catchment litter management and waste collection as these affect water service delivery as discussed later in the chapter. Put simply, it is the management of water in the urban environment so as to minimize the impact on rural water resources (quantity and quality), and maximize its utility within the town or city (Armitage, 2006). Figure 2.3 illustrates the three main components of IUWM.

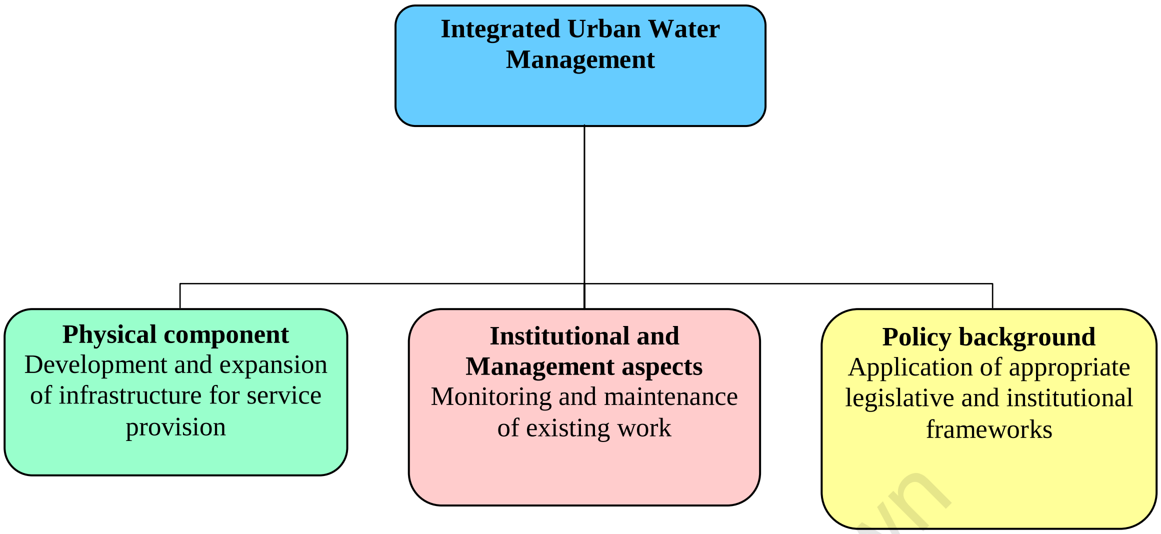

Figure 2.3 Components of IUWM (After Kluge, 2007)

Experience in many countries over the last several years has shown that creating an effective IWRM strategy requires a somewhat different process than that entailed in creating a once-off water resources planning document (Kluge, 2007). Key differences include involvement from multiple sectors, broader focus, dynamic rather than static frameworks and strong stakeholder participation (Kluge, 2007). Moving towards an IWRM approach at the national level requires positive change in the governance of water related issues. This requires a transformation of the range of political, social, economic and administrative systems that are in place to develop and manage water resources and deliver water services at different levels of society (African Environmental Development, 2007).

2.3.2 Key principles of IWRM and IUWM

Conceptually, IWRM approaches should promote coordinated development and management of water, land and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (Kluge, 2007). Operationally, IWRM approaches must involve the application of knowledge from various disciplines as well as the insights from diverse stakeholders to devise and implement efficient, equitable and sustainable solutions to water and development problems (Kluge, 2007). At the Mexico 4th World Water Forum in 2006, one of the stated principles was that the adoption of IWRM approaches requires technical capacities in a number of specialized areas as well as long-term capacity building. In addition, indicators need to be defined and benchmarks established, as well as the setting up of monitoring and evaluation mechanisms. This ensures that activities are regularly assessed and progress is made towards problem solving (WWC, 2006).

Another key principle lies in formulating a financing strategy to reconcile the often competing goals of economic efficiency, social equity and environmental sustainability. The vision of IWRM provides the working basis for all UN organizations concerned with water-related problems as well as for the international and national financing organizations in the various countries committed to adopting an IWRM approach (Kluge, 2007). Table 2.2 summarizes the main advantages of adopting an IWRM approach.

Table 2.2 Advantages of an IWRM approach (adapted from WWC, 2006)

Advantage	Explanation
IWRM is a good problem solving approach	Many countries are experiencing water-related problems that are proving intractable to conventional approaches. Problems such as drought, flooding and escalating conflicts over water usually require cooperation from multiple sectors. IWRM makes identifying and implementing effective solutions much easier.
IWRM avoids costly mistakes and encourages sound investments	Decision-making based on a short-term, sectoral view is rarely effective in the long haul and can result in some very expensive mistakes in terms of unsustainable gains, unforeseen consequences, and lost opportunities. IWRM promotes considering economic implications and environmental impacts from the outset.
IWRM approaches get the most value for money from investments in infrastructure	Planning, designing and finally managing infrastructure using an IWRM approach ensures maximum returns, both social and economic, on investments.
IWRM approaches promote the strategic allocation of water	Strategic allocation requires subordinating the needs of individual sectors and user groups to the larger goals of the society. An IWRM approach frees countries to look at allocation in the context of the 'big picture' of sustainable development goals.

While IWRM is generally applied at regional or national level, Integrated Urban Water Management (IUWM) is the component of IWRM which is applied to urban centres. IUWM deals more intensely with the interaction between people and their water needs and the natural and constructed systems within which they live. Service provision, management of urban rivers, waste management and disaster management all become critical in ensuring a sustainable environment. De Carvalho (2007) breaks IUWM into three components: the physical component which mainly consists of the physical infrastructure and its development, the institutional and management aspects, which deal with the programmes in place to ensure the most efficient use of available resources, and the policy background which supports development generally through legislative corridors. The sustainability index expounded upon in this thesis attempts to address all three components of this complex research area with the aim of highlighting issues in management. Another way in which the intricacies of IUWM can be better understood is through having a closer look at the different aspects of water services management.

IUWM challenges the view of urban water service provision being a purely technical function, resting within the realm of engineers and scientists alone. The change from traditional practice to IUWM has considerable social and economic implications for urban communities and the range of public and private institutions providing urban water services to that community. Increasingly, integration is being encouraged in managerial functions, organizational structures and in legislation as set out in the Johannesburg Plan of Implementation in 2002 (UNDP, 2005). IUWM can be achieved if the organizations responsible for the different parts of the urban water cycle are prepared to work together and share knowledge and information (Fletcher & Deletic, 2008).

2.4 Aspects of water services management

The main objective of water services management is to provide a wide range of goods and services, including water itself and the related services and benefits. Integrated management promotes a broader, multidisciplinary approach that accounts for the complexities of the urban water system. IUWM is holistic in its approach and is characterized by involving local and regional authorities, employers, environmentalists, decision-makers and politicians. The greatest challenge encountered in the implementation of integrated water management is the creation of cross-sectoral co-operation amongst the different services in IUWM (Geiger & Hofius, 1995). Typical services provided to urban populations include water supply, wastewater treatment and disposal, drainage and provision of water as a general amenity. The urban water cycle and these services are discussed in detail in the following sections.

2.4.1 Urban water cycle

In South African cities such as Port Elizabeth and East London, the urban water cycle is currently managed as a set of separate water supply, wastewater and stormwater disposal processes. Research shows that a systems approach is required to understand and hence find optimum solutions for urban water cycle management that include decentralized approaches used to supplement current centralized management methods (Coombes & Kuczera, 2002). IUWM encourages a systems approach. The interconnected nature of the urban water cycle may be illustrated in a number of ways. For example, stormwater is traditionally considered a nuisance and is conveyed away from areas as quickly as possible, potentially reducing groundwater resources whilst eroding and degrading rivers and wetlands. Another example is the use of dry sanitation options in densely-populated low-income areas which can lead to greywater disposal problems. Figure 2.4 illustrates the water cycle as it applies to an urban setting, deviating slightly from the more simplistic natural water cycle.

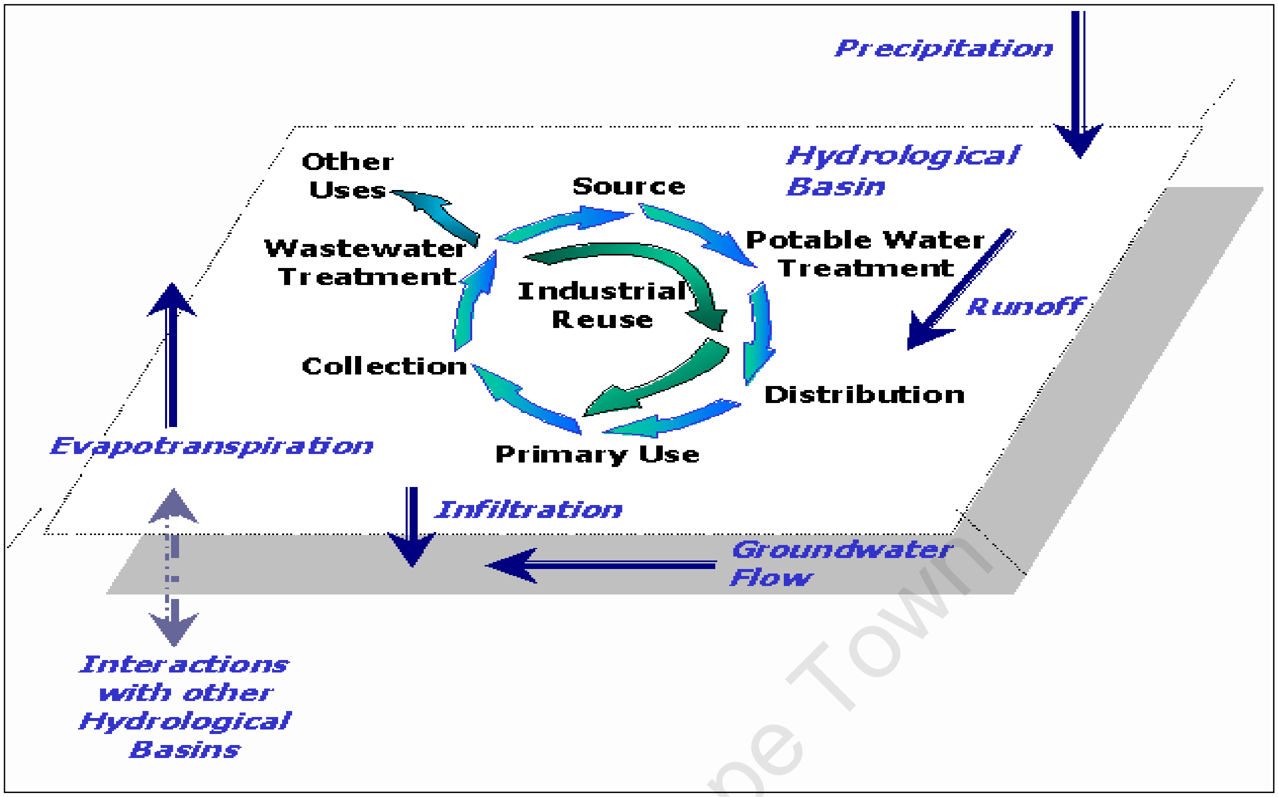

Figure 2.4: Urban water cycle (UNU-INWEH, 2006)

It appears that sustainable water services will only be achievable if the planning of all the considered urban services is done as a whole. This is illustrated with the "Rubik's cube" analogy depicted in Figure 2.5 (Armitage, 2006).

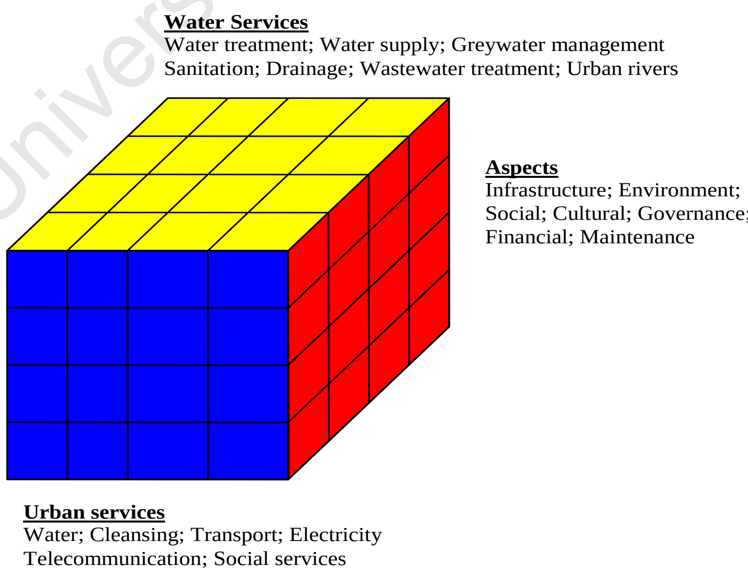

Figure 2.5: The "Rubik's cube" of urban water services (Armitage, 2006)

Urban water systems contain many components which collectively provide water supply to urban populations as well as sanitation, flood protection, surface and groundwater management. Urban water systems also contain components which serve the environment through ecosystem maintenance and protection. Consideration of the interactions within the urban water system is necessary in order to better understand IUWM (Fletcher & Deletic, 2008). To achieve integration of the whole system, it is also important to ensure integration of the team of people involved in management. In the past water managers have generally dealt with municipal services by way of a fragmented approach which has led to conflicting interests within governing bodies, resulting in poor utilisation of financial and physical resources (Fletcher & Deletic, 2008). All levels of government need to find appropriate ways to manage every aspect of the urban water cycle in a holistic manner through coordinated policy-making, planning and implementation. Holistic management involves coordination between the bio-physical systems and socio-economic activities which create demands for freshwater and generate wastewater. An understanding of the interactions between the components of an urban water system is also important in monitoring sustainability performance. If it is known where breakdowns in the system are occurring, the most relevant data can be collected which in turn can indicate the extent to which progress is being made towards sustainability.

2.4.2 Water Supply and Demand

The Mar de Plata Conference held in 1917 in Argentina was one of the earliest international efforts towards addressing global water problems. Basic human needs for water were articulated at the conference, by declaring that:

"…all peoples, whether their stage of development and their social and economic conditions, have the right to have access to drinking water in quantities and of a quality equal to their basic needs" (United Nations, 1977).

However, the reality is such that in many countries such as Somalia and India, domestic per capita water withdrawals range from 4.5 to 48.2 litres/person/day (ℓ/c.d) and fall below the basic water requirement (BWR) of 50 ℓ/c.d recommended by the United Nations (UN, 2006). The demand for water is growing in South Africa, and with the rapid expansion of urban areas, many communities are or will be entering a state of continuous water stress (DWAF, 2003). Water stress occurs when the demand for water exceeds the available amount during a certain period (DWAF, 2003). The failure to meet basic water needs is costly with respect to both social and economic aspects. Inadequate water supply and sanitation severely impact on human health through *inter alia* water-related diseases (UNDP, 2005).

2.4.2.1 Water provision

In order to provide everyone with access to an adequate amount of good quality water for drinking and personal hygiene on a permanent and regular basis the following three aspects need to be considered (Graham, 2003);

- Quality: The water must be free from pathogenic organisms and chemical contaminants in concentrations greater than prescribed limits (DWAF, 2004)
- Quantity: The World Health Organisation (WHO) recommends a minimum daily consumption of 50 litres per capita per day (ℓ/c.d). In South Africa, the basic minimum is access to 25 ℓ/c.d but the target for urban areas is 50 ℓ/c.d (UN, 2006)
- Reliability: It would be desirable to provide a constant 24hr service. However, if this is not possible, then consumers should know exactly when water is available. South Africa's DWEA regulations state that "no consumer should be without water for more than seven days a year, supplied from a source of raw water which is available 98% of the time, not failing more than once in 50 years" (DWAF, 2004)

DWEA classifies water supply systems in groups according to the level of service from 'rudimentary' to 'full service' (DWAF, 2004). Graham (2003) used four levels to describe all the distribution systems currently available in South Africa, as illustrated in Table 2.3. The different levels indicate increases in quantity, pressure, access or convenience.

Table 2.3 Classification of water service provision (Graham, 2003)

Rudimentary	Basic	Intermediate	Full
• Direct abstraction from rivers and wells • Vendors • Public tankers • Water kiosks • Concession sales • Communal standpipes with limited access	• Communal standpipes with a set distance to every dwelling	• Yard taps • Yard tanks • Roof tanks	• House connections

2.4.2.2 Water demand management

Water demand management (WDM) is a management technique used to reduce the amount of water needed and used by consumers. The key focus areas for WDM (Jacobs, 2008) are to:

- Reduce non-revenue water losses
- Reduce water wastage by all consumers
- Reduce projected potable water demand
- Adopt WDM as one of the key water service delivery strategies, giving priority to its implementation and ensuring ongoing adequate enabling environment
- Ensure ongoing effective management systems and implement Integrated Water Resource Planning in all decisions with respect to water resource augmentation, bulk infrastructure development and water efficiency projects

WDM consists of three main elements as illustrated in Figure 2.6. These elements are assisted by projects, programmes and campaigns such as the National Water Conservation and Demand Management Strategy (DWAF, 2004). Residential water use is one component of the urban water use profile which also comprises industrial, business, commercial, institutional and municipal water use, as well as water loss. One of the aspects of water demand management (WDM) is to influence how water is used at home (Jacobs, 2007). Jacobs & Haarhoff (2007) adopted terms from management to describe different approaches to managing water use. *WDM measures implemented by a water authority can be viewed as 'top-down' (TD) measures. Subsequently, consumers are compelled, or at least encouraged, to implement some 'bottom-up' (BU) WDM measures at home to react to the changes brought about by the water authority* (Jacobs & Haarhoff, 2007).

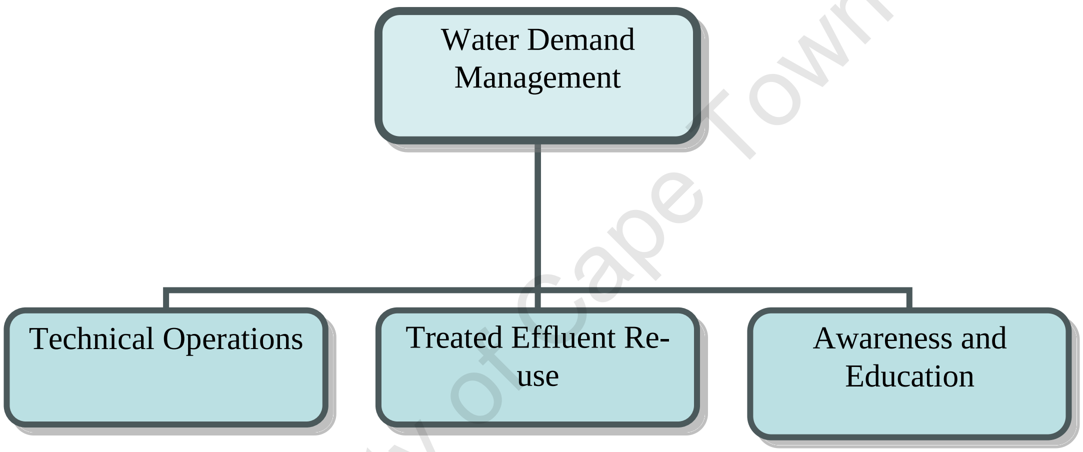

Figure 2.6: Elements of Water Demand Management (Jacobs, 2008)

Within a residence, variations in water use habits also influence hot water volume, return flow volume to the sewerage system and the quality of such wastewater (Jacobs, 2007). This influences the energy used and wastewater management - an important linkage often ignored. Comprehensive information on the water used on a particular property is needed in order to better manage how and when water is used (Jacobs, 2007). In South Africa, residential water use is usually metered locally for the purpose of billing consumers. The meter reading is typically read on a monthly basis and the information is transferred from meter readers' files to financial billing systems. This process is labour intensive however it does help in the management of water use.

2.4.3 Sanitation

Providing basic sanitation facilities for the poor is one of South Africa's major challenges. There has been an increase in the number of poorly designed and poorly operated water-borne sewerage systems, especially in urban areas. The health impacts on the affected communities and on the environment are serious when sanitation systems fail or are inadequate (DWAF, 2002).

Adequate sanitation matters for a range of reasons such as:

- Providing privacy, dignity, convenience and safety for individuals
- Reducing pollution impacts, especially on water sources
- Reducing incidence of diarrheoa and cholera cases
- Poverty reduction, through reducing vulnerability to disease and allowing low-income people to make better use of their resources (DWAF, 2002)

Maintaining the infrastructure already in place is an added challenge for municipalities already having to deal with restructuring, staff shortages and budget cuts. Cities are struggling to reduce housing backlogs, while the rapid growth of informal settlements is putting pressure on service delivery. As a result, many local authorities have resorted to 'temporary solutions' such as bucket systems and chemical toilets (DWAF, 2002). These are unpopular with residents, expensive to run, and often become a permanent fixture in the community rather than the intended temporary status. Graham (2003) classifies sanitation systems as illustrated in Table 2.4 with examples of each category.

Table 2.4: Sanitation system classification (After Graham, 2003)

Dry System	Wet System
On-site • Ventilation Improved Pit (VIP) toilet • Reid's Odourless Earth Closet (ROEC) • Composting toilet • Chemical toilet	On-site • Pour Flush toilet • Aqua privy • Septic tank
Off-site • Bucket toilet • Vault and vacuum tanker	Off-site • Conventional sewerage • Settled sewerage • Simplified sewerage • Vacuum sewerage

High capital costs, lack of water, no spare capacity in the current treatment systems and difficult terrain rule out the provision of flush toilets for all. The lack of money for new works is not the only constraint when it comes to sanitation, therefore affordable, sustainable and acceptable options are needed in the interim (DWAF, 2002). Increasing numbers of municipalities in South Africa are exploring alternatives to conventional water-borne sanitation.

There are a range of alternatives in use such as double pit VIPs, urine diversion systems, low flow systems, shallow sewers, and solids free systems (DWAF, 2002). It is important to note that there is no one 'best option'. Each situation is different and every technical option functions best in the environment for which it was designed (DWAF, 2002). For that reason, decision-makers need to familiarize themselves with the options available, and understand their particular operating requirements, cost implications and limitations. This information should be shared with users, and users must be involved in the decision-making process to increase community acceptability of the service option chosen.

It has been shown from studies in developing countries that impacts on public health from improving water and sanitation systems vary depending on local conditions in the country under review. Yet, the overall trend is that improved water supply results in reduced mortality, and the impacts are bigger when sanitation and health education are introduced (Ashley & Cashman, 2005). In South Africa's informal settlements, the person to toilet ratio can be as high as 40 persons per toilet (Barnes, 2008). This results in serious health implications, which can have fatal consequences. Poor solid waste removal also causes contamination of the water system. Informal settlement dwellers often have no means of disposing of greywater, forceing residents to use stormwater drains to discard this waste. Such activities encourage the growth and accumulation of bacteria such as *E.Coli* and other disease causing organisms (Barnes, 2008). For municipalities, there are significant costs involved in dealing with the health implications of inadequately provided or maintained services. Therefore, securing clean water and safe sanitation should be top priority in development strategies.

The development of adequate water-related infrastructure that meets sustainability goals is the ultimate challenge for scientists, technicians and water and sanitation management decision-makers. In order for integrated system (such as IUWM) solutions to be effective however, sustainability criteria should be introduced at the level of long-term physical planning and should guide all subsequent detailed planning and implementation (Niemczynowicz, 1999).

2.4.4 Drainage

Protection of the society, material property and business activities against flooding and inundation is one of the basic goals of water management, and as such, flood protection and drainage are very important in urban settlements. Graham (2003) defines drainage as the process of removing unwanted water from an area. Waterborne sanitation is a part of drainage. Graham goes on to explain that urban drainage deals with two different kinds of excess water; namely, stormwater and wastewater. Stormwater is precipitation that travels along the surface (and to a lesser extent, subsurface) as runoff, and household wastewater consists of greywater or sullage from washing, cleaning and cooking, and blackwater from flush toilets (Graham, 2003). Drainage seeks to prevent or reduce the impact of flooding and the associated health risks particularly in poorly serviced and low-income settlements.

The problems noted by Graham (2003) of poorly managed stormwater and wastewater include:

- small floods damaging roads and buildings causing disruption to lives and businesses
- pollution from overflowing latrines and sewers, causing faecal pollution and disease
- cross contamination of water supplies
- wet soils leading to ideal conditions for worm infections
- providing habitats for vectors (e.g. mosquitoes and snails)

- water pollution from diffuse sources (rubbish, animal faeces, air pollutants)
- erosion of water courses
- siltation of water courses
- inconvenience (e.g. wet feet in puddles)
- safety (e.g. physical danger of being washed away)
- landslides.

One solution to the problems associated with poorly managed drainage and its impact on the urban hydrological cycle is the adoption of a design philosophy called Sustainable Urban Drainage Systems (SUDS). SUDS attempt to imitate the pre-development situation with respect to both runoff quality and quantity. SUDS aim to restore the pre-development urban hydrograph by increasing infiltration and decreasing runoff (Graham, 2003). Usually conventional drainage systems do not address the issue of increased runoff because of development. In the application of SUDS one major challenge is that it is relatively difficult to retrofit SUDS to existing development. They are generally used on the periphery of urban areas and for new developments (Graham, 2003).

Research shows that SUDS are more sustainable than conventional drainage methods (Graham, 2003) because they:

- allow authorities to manage runoff flow rates, reducing the impact of urbanization on flooding
- allow authorities to protect or enhance water quality
- are sympathetic to the environmental setting and the needs of the local community
- provide a habitat for wildlife in urban watercourses and
- encourage natural groundwater recharge (where appropriate).

SUDS do this by allowing those who manage them to:

- deal with runoff close to where the rain falls
- manage potential pollution at its source now and in the future and
- protect water resources from point pollution (such as accidental spills) and diffuse sources.

SUDS produce an urban hydrograph that manages flooding and ultimately enhances the environment (Graham, 2003).

2.4.5 Catchment litter management

Litter is a worldwide problem that has serious consequences on drainage systems. For efficient and effective service delivery, catchment litter needs to be adequately managed. Sources of litter include; household waste, commercial waste dumpsters, construction activities, pedestrians and motor vehicles.

An Integrated Catchment Litter Management Strategy has three main components (Armitage, 2008):

1. *Planning controls* – these are aimed at adopting land-use policies which;
   - preserve existing valuable elements of the stormwater system, such as natural channels, wetlands and riparian vegetation by restricting the use of such areas
   - minimize the risk of litter reaching the drainage system by situating litter producing activities in areas where it is possible to contain and control litter accumulation more easily
   - require pollution control measures as part of any development application
2. *Source controls* – these focus on land management, education and awareness
   - Activities for land management include, upgrading cleansing operations by for example, increasing the frequency of collections. Improved control of construction activities also forms part of land management
   - Education and awareness can be improved by conducting business surveys and running litter education campaigns. Stricter enforcement of anti-litter legislation promotes improved litter management
3. *Structural controls* – involve improved stormwater treatment and the construction of litter traps

When a city has a Catchment Litter Management Strategy in place, it results in significant cost savings (Armitage, 2008). Fewer financial resources would need to be used to repair drainage systems that have become dysfunctional due to litter accumulation. Within the context of IUWM, a Catchment Litter Management Strategy should form an integral part of water service delivery.

2.4.6 Rehabilitating urban rivers

Urban rivers face challenges of canalization and urban encroachment as a result of city development and growth. These changes influence the rivers' quality and structure. In South Africa, river rehabilitation is a relatively new field and most projects are done on a trial and error basis (Day, 2008). When dealing with urban rivers, there are four main 'intervention' approaches. These are restoration, rehabilitation, remediation and enhancement. The type of intervention chosen is based on the history of the river, its present state and the desired outcome.

The restoration of a river is the process of returning an ecosystem as closely as possible to pre-disturbance conditions and functions. This entails the restoration of the natural water quality, sediment and flow regimes, riparian community and channel stability. Remediation involves improving the current state of an ecosystem without reference to its initial state (Day, 2008). The main challenge with improving a river system is that some urban rivers and wetlands have been changed so greatly that the pre-disturbance condition is unclear. Planning is very important when it comes to urban river interventions as it allows funds to be harnessed effectively when available.

Planning also facilitates the sensible phasing of activities and this gives time for adequate research to be carried out (Day, 2008).

2.4.7 The management of water services infrastructure

The goal of infrastructure asset management is to meet a required level of service in the most cost-effective way through the creation, acquisition, maintenance, operation, rehabilitation and disposal of assets so as to provide for present and future customers. Infrastructure networks provide the platform for economic and social development in cities. Good quality infrastructure is the cornerstone of public health and safety, therefore to safeguard long-term returns to stakeholders risk management practices need to be in place (Del Mistro, 2008).

Infrastructure assets are stationary systems that serve defined communities where the system as a whole is intended to be maintained indefinitely to a specified level of service. This is achieved by the continual replacement and refurbishment of its components (Del Mistro, 2008). Examples of infrastructure assets are transportation networks, energy supply networks and water utilities (water supply, wastewater and stormwater systems).

The benefits of improved asset management are related to trade-offs with accountability, service management, risk management and financial efficiency. Asset management results in improved stewardship and accountability. The communication and relationship with service users also improves (Del Mistro, 2008). Asset management also reduces risks of asset failure by assessing the probability of occurrence and putting in place necessary measures to avoid damages to the infrastructure.

2.5 Assessing progress towards sustainable development

2.5.1 Theory of sustainability indicators

There has been an increasing desire to measure and describe different aspects of sustainability, with the focus often being on environmental aspects (Lundin & Morrison, 2002). Sustainability indicators at the national, regional and local level have become common assessment tools. There is a growing need to establish appropriate indicators to allow decision makers to make informed judgements regarding policies, programmes, plans and projects (Donnelly *et al.*, 2007).

The European Environment Agency's definition of an indicator is "*a measure, generally quantitative, that can be used to illustrate and communicate complex phenomena simply, including trends and progress over time*" (Donnelly *et al.*, 2007). An indicator provides a clue to a matter of larger significance or makes perceptible a trend or phenomenon that is not immediately detectable. In other words, indicators are measureable aspects of a project, environment or society that can be used to monitor its progress or direction (Donnelly *et al.*, 2007). The US Environmental Protection Agency (USEPA) defines an environmental indicator as "*a measureable feature or features that provide managerial and scientifically useful evidence of environmental and ecosystem quality or reliable evidence of trends in quality*" (USEPA, 2009). Consequently, environmental indicators should be measurable, scientifically valid and capable of providing information for management decision-making. A key function of an indicator is to reduce the volume and complexity of information which is required by decision makers. Lundin & Morrison (2002) state that it is not necessary for the decision maker to know the detail behind indices but it is the job of the indicator to relay this complex information in an accurate and understandable manner in order for informed decisions to be taken.

Indicator development is always a two-way process (Valentin & Spangenberg, 2000). Indicators are not only designed for policy making, but they also help to concretize and mould them. Therefore developing indicators cannot be a purely technical or scientific process. Rather, Valentin & Spangenberg suggest that it should be an open communication and policy process. Indicators suitable for this purpose must be simple and directionally clear, that is:

- the number of indicators must be limited and the method of calculating them transparent
- they should indicate items and trends obviously relevant in terms of importance for sustainability, and that they are sensitive, i.e. able to signal progress or the absence of it (Valentin & Spangenberg, 2000).

2.5.2 Purpose and qualities of indicators

In order to bring about more sustainable development whilst safeguarding the environment, it is important to know how well a nation is achieving this objective. Agenda 21 encourages the use of indicators of sustainable development which describe the current state of the economy, environment and society (Robert *et al.,* 2002). Indicators can help to monitor progress towards sustainable development, and identify where improvements need to be made.

According to Miller (2007) and United Nations (2001), indicators are designed to fulfil the following tasks:

- To generate a simplified but reliable description of reality, helping to identify the core problems and permitting to develop adequate and effective solutions in line with long term sustainable development targets. If at all possible targets should be quantitative, or at least defined by directionally safe imperatives. Such indicators must be reproducible, i.e. based on a sound scientific basis; robust, i.e. immune against those small variations in data and methodology that do not indicate a changing trend, and general, i.e. not specific for a single case but applicable in the whole territory.
- To provide early warning signals on the success or failure of policies adopted. Indicators must also guide the data collection process.
- To pass the message about the challenges of sustainable development, the policy programs developed and implemented, as well as about results achieved so far and the setbacks suffered to the public at large. To serve these communication purposes, they must reduce complexity in a plausible and meaningful manner, be limited in number and thus be easily understandable. They should help structure the debate in a clear and simple way that is easily digestible by the audience.

Wide-spread efforts toward indicator development are motivated by the proper construction of suitable sets of indicators (UN, 2001). However, some of these demands are contradictory, as a complete but comprehensive and easily communicable system of indicators is a kind of oxymoron (Miller, 2007). Consequently, the suitability of indicators is dependent on the purpose for which they are designed and used.

2.5.3 Indicators in decision-making

Indicators can provide crucial guidance for decision-making in a variety of ways. Firstly, indicators can translate physical and social science knowledge into manageable units of information that can facilitate the decision-making process. They can help to measure and calibrate progress towards sustainable development goals by providing an early warning system to prevent economic, social and environmental damage (UN, 2001).

The 1992 Earth Summit recognized the important role that indicators can play in helping countries make informed decisions concerning sustainable development. This recognition is articulated in Chapter 40 of Agenda 21 which calls on countries to develop and identify indicators of sustainable development that can provide a solid basis for decision-making at all levels (UN, 2001). Moreover, Agenda 21 specifically calls for the harmonization of efforts to develop sustainable development indicators at the national, regional and global levels, including the incorporation of a suitable set of these indicators in common, regularly updated and widely accessible reports and databases (UN, 2001).

2.5.4 Monitoring and evaluation systems for IUWM

A good monitoring and evaluation system lays the foundation for on-going and effective decision making when it comes to sustainability strategies for IUWM. Water managers and decision makers need to know their progress, where the problems lie and what needs to be done to move towards more efficient and sustainable systems. A strong monitoring and evaluation system should encourage positive change and should allow for adaptation of strategies given evolving needs and conditions (GWP TEC, 2006).

Firstly, it is important to monitor the implementation process in order to ensure that the actions and the allocation of resources outlined in the strategy are progressing efficiently. These actions could include service delivery through investment in infrastructure, changes in policy or even changes in management structures. The outcomes of these actions also need to be monitored and consequently the progress towards achieving the strategy's goals and objectives needs to be evaluated in order to provide a knowledge platform upon which the strategy can be improved and enhanced (GWP TEC, 2006). Key to this whole process is the capture of relevant data which can be translated into a number of indicators and composed into a meaningful composite indicator.

A monitoring and evaluation system is generally intended to function within the management or governance sphere and would be most useful in South Africa if it occurred at local government level. It is however anticipated that this research and subsequent studies done on the development of a sustainability index for IUWM would be a catalyst for change in management practices within the water sector. The following section discusses some well-established and frequently-used measures of sustainability. It is hoped that a study of these examples will inform the improvement of the SI being evaluated in this research.

2.6 Measuring sustainability

The following are some examples of measures of sustainability. This selection represents only a small proportion of the various indicators of sustainability used today. These were chosen due to their significance in improving the sustainability index for IUWM.

2.6.1 Environmental Life Cycle Assessment (ELCA)

Environmental Life Cycle Assessment provides the necessary instrument to assess and quantify the environmental burden of a specific material or service taking into account its entire cycle, from ‘cradle-to-grave’ (Robèrt *et al.,* 2002). This tool enables both qualitative and quantitative assessments, impact analysis and identification of opportunities for improving or eliminating these burdens on the environment. ELCA looks to detailed analysis of individual materials or services. If a broader assessment of material flows within a system is required, then TMF (total material flow) analysis is more appropriate. This provides an understanding of the flows of materials and energy at a macroeconomic level. In answer to criticisms that ELCA is not a practical tool, some researchers have proposed streamlining it. Streamlining is introduced primarily in the initial, goal definition stage and objectives are adjusted to comply with the needs identified by the end-users and the level of accuracy desired. In this way, ELCA can become more practical for use in a variety of settings and for a variety of end-users (Robèrt *et al.,* 2002).

2.6.2 Human Development Index

Initially developed in 1990 by Pakistani economist Mahbub ul Haq, the Human Development Index (HDI) has become an integral part of the work done by the UNDP on human development (UNDP, 1994). Since 1993 it has featured prominently in the annual Human Development Report (UNDP, 1994). In essence, this composite index traces the level of development of countries across the globe and provides comparative measures through the analysis of four components which fall under one of the following three categories (UNDP, 1994):

- Health and well-being, assessed on the basis of life expectancy from birth
- Literacy and education, measured through school enrolment rates and adult literacy levels
- Standard of living, which makes use of the log of per capita Gross Domestic Product (GDP) at Purchasing Power Parity (PPP) expressed in US Dollars

The aim is to assess a country’s performance along the development continuum, determining whether it is developed, developing or underdeveloped. Furthermore, it employs a ranking system for the 175 UN member countries included. Monitoring of a number of socio-economic, political, cultural and environmental issues is undertaken and compared to the progress achieved under each of the basic categories of the index (UNDP, 2005). The Human Development Report provides a comprehensive list of these, recording their achievements. The HDI relates to urban water management in that it gives an indication of the social sustainability of an area and this influences the water management strategies employed in the area.

2.6.3 Ecological Footprint

The concept of an ecological footprint was initially introduced by a Canadian ecologist, William Rees. It allegorically describes the amount of land and water required by a human population for survival and attainment of sufficient resources for life as well as absorption of wastes, given contemporary technologies (Rees, 1992). In more current terms, the ecological footprint is used as a measurement and management tool to assess and indicate the environmental sustainability of systems and networks. It is a tool that influences policy-making and decision taking. It creates awareness of the environment and human impact on it (Robert *et al.*, 2002). The aim of the ecological footprint in some aspects is to draw attention to current unsustainable resource consumption patterns and to the need for allowing recharging and restoration of the environment. By doing so it promotes more efficient use of resources. It is a strong social tool and can create awareness of the environment and people's impact on it.

Some valid criticisms of this method have been raised. For one it was developed and initially adopted by developed countries of the Northern hemisphere; consequently criteria and indicators might have little relevance to the needs and priorities of poorer populations (Robert *et al.*, 2002). Although resource consumption can be and is extensive, it is so for a number of diverging reasons. Secondly, the indicator makes rather simplistic assumptions and rough estimations. For example, multiple land uses are not considered. Another criticism of the ecological footprint is that the tool is too simplistic; however, this does not detract from its shock value and ability to influence policy decisions (Robert *et al.*, 2002). The EF relates to urban water management in that it gives an indication of the amount of water needed by a population in a given area. This is helpful because if an area presents an unsustainable water need in terms of the EF then strategies can be put in place to lower the population's water use.

2.6.4 Environmental Sustainability Index

The Environmental Sustainability Index (ESI) benchmarks the ability of nations to protect the environment over the next several decades (Yale & Columbia University, 2005). The ESI does so by integrating 76 data sets tracking natural resource endowments, past and present pollution levels, environmental management efforts, and the capacity of a society to improve its environmental performance into 21 indicators of environmental sustainability (Yale & Columbia, 2005). The ESI is generally used at city, region or country level, though it has also been used to assess the environmental performance of infrastructure, agriculture and production (Lundin & Morrison, 2002).

The ESI is a powerful tool for analytically assessing environmental sustainability and is also a strong policy-guiding instrument. It also provides significant benchmarking facilities between the various countries and stimulates positive competition both in general and within cluster areas. Furthermore it provides the opportunity to showcase and encourage appropriate policy approaches, institutional structures and technologies. The indicators in the ESI fall within the five broad categories listed below. They represent common issues and concerns expressed in literature and by many stakeholders, including those at government level:

- Environmental systems
- Reducing environmental stresses
- Reducing human vulnerability to environmental stresses
- Societal and institutional capacity to respond to environmental challenges
- Global stewardship.

With regard to urban water management, environmental sustainability is very important for the sustainability of the water system in a given area. The ESI of an area can give an indication of the environmental concerns which ultimately affect the water resources.

2.6.5 Water Poverty Index

The original concept of the Water Poverty Index was created by Sullivan (2002), building on the hydrological modelling work of Lawrence *et al.* (1999). It was designed as a holistic tool, to capture the links between water availability and livelihoods while at the same time addressing the need to maintain ecological integrity. By using an integrated index structure, it was designed to be a water management tool that is accessible to water decision-makers at various levels. The overall structure and the component variables of the Water Poverty Index were identified through participatory consultation with scientists, water managers and stakeholders. The resulting structure is believed to capture a more comprehensive picture of water management challenges (Sullivan, 2002). The components are:

- Resources – a measure of the water available, taking account of seasonal and inter-annual variability and water quality
- Access – a measure of how well provisioned the population currently is, including for domestic use and irrigation;
- Capacity – to manage water resources, based on education, health and access to finance;
- Use – this captures the use of water, and its contribution to the wider economy;
- Environment – this tries to capture the environmental impact of water management, attempting to ensure long term ecological integrity.

The individual variables for each component need to be selected through a stakeholder process to ensure that they are available and they reflect the stakeholder's main concerns (Sullivan, 2002).

2.6.6 Disaster Risk Index

The Disaster Risk Index (DRI) provides a measure of the national mortality risk due to exposure to certain disasters such as earthquakes, tropical cyclones, floods and droughts. It also considers social and economic aspects that either contribute or can be linked to the risk of death. This indicator fails to address other facets of risk however, which do not directly threaten life, i.e. loss of livelihood, economic costs to individuals and society at large (UN, 2001).

The indicator encapsulates the definition of risk, which states that risk arises as a result of exposure to a hazard which is compounded by a specific group's vulnerability to it. The risk indicator therefore adopts the following conceptual framework (UN, 2001):

Risk= Hazard x Exposure

Risk is dependant on the probability of the occurrence of a hazard and the exposure of a given group to that hazard. This does not explain the different impacts similar hazards have on areas experiencing similar levels of exposure. The missing variable is vulnerability, which assesses both the adaptive and coping capacity of groups to deal with hazards. The emphasis is therefore on vulnerabilities to the hazard and not the hazard *per se,* which is often uncontrollable in any case (UN, 2001).

2.6.7 Gini coefficient

The Gini coefficient is commonly used as a measure of inequality of wealth or income. A low Gini coefficient indicates a more equal distribution, with 0 corresponding to a perfect equality, while higher Gini coefficient indicate more unequal distribution, with 1 corresponding to perfect inequality (UNDP, 2005). The coefficient can be used to compare income distribution across different population sectors as well as countries, for example the Gini coefficient for urban areas differs from that of rural areas in many countries. It can also be used to indicate how the distribution of income has changed within a country over a period of time, thus it is possible to see if inequality is increasing or decreasing (UNDP, 2005). In the context of urban water management, it is important to be aware of the inequality in an area as it influences and guides the focus of water services investment.

2.6.8 The River Health Index

Amongst various other measures of sustainability, South Africa's River Health Index (RHI) focuses on the sustainability of rivers (Uys, 1994). The RHP was initiated in 1994 as a response to the need for more detailed information on the state of South Africa's aquatic ecosystems, at a time when the Department of Water Affairs & Forestry's (DWAF) management focus was broadening from end-of-pipe monitoring to an integrated water resource management approach (Uys, 1994). This research seeks to include the RHI as an indicator in the current SI. Ian Player (1963) stated that '*one can determine the state of an urban environment by the state of its rivers.*' For this reason, including the RHI into the current SI may assist in assessing the sustainability of water management in the cities.

Healthy rivers provide goods and services such as water supply, breakdown of pollutants, conservation, flood attenuation, natural products and recreation. These all contribute to human welfare and economic growth. When people use rivers their activities impact on the rivers' health. The South African River Health Programme (RHP) assesses the health of rivers by measuring selected ecological indicator groups that represent the condition of the larger ecosystem (RHP, 2005). The data are simplified and represented as indices. Biological monitoring of this kind is based on the assumption that the condition of an ecosystem can be assessed by measuring the condition of aquatic communities. This technique develops a holistic understanding of riverine health rather than a 'snapshot' of water quality conditions as do chemical sampling techniques (Haskins, 2008). The RHP thus focuses on selected indicators that are relatively easy to measure and are representative of the ecosystem, e.g. aquatic invertebrates, fish, riparian vegetation, habitat quality. Many physical, chemical and biological factors influence river ecosystem health. The RHP focuses on selected ecological indicator groups that represent the larger ecosystem and are feasible to measure (River Health Programme, 2005).

The RHP utilises five descriptive categories of river condition and expresses results of surveys on maps. The categories are shown in the Table 2.5.

Table 2.5 Categories of river condition (RHP, 2005)

Category	Description
Natural	No or negligible modification (relatively little human impact)
Good	Biodiversity and integrity largely intact (some human-related disturbance but ecosystems essentially in good state)
Fair	Sensitive species may be lost, with tolerant or opportunistic species dominating (multiple disturbances associated with socio-economic development)
Poor	Mostly only tolerant species present; alien species invasion; disrupted population dynamics; species are often diseased (high human densities or extensive resource exploitation)
Unacceptable	River has undergone critical modification, almost complete loss of natural habitat and indigenous species with severe alien invasion

2.7 Development of the Sustainability Index for IUWM

De Carvalho (2007) developed an index which, through a wide range of indicators, would assess the sustainable water management capacity of a city or portion thereof. This study forms part of an initiative undertaken by the University of Cape Town which specifically focuses on the sustainability of integrated urban water management in urban areas of Southern Africa.

In constructing the SI, De Carvalho (2007) drew considerably on existing methodologies and approaches from work done by Stoeckigt (2006) and Nardo *et al*. (2005) . In particular the work of Nardo *et al*. (2005) provided guidance in the development of the composite index with a step-wise methodology. Nardo *et al*. (2005) proposes the following steps in constructing a composite index:

1. Building a **theoretical framework** which will provide the underlying basis for indicator selection and support the overall indicator structure.

2. **Indicator selection**, termed ‘data selection’, involves the selection of appropriate indicators for the field of research, given their relevance to current issues, their appropriateness to the area in question, their scientific and analytical basis and ability to effectively represent the issues they are designed for (measurability).

3. **Multivariate analysis** requires an investigation to assess the overall indicator structure, given the various assumptions made in the development process.

4. **Imputation of missing data** involves looking at the steps followed, in order to arrive at acceptable datasets, and where data is missing, determining how to address the issue.

5. **Normalisation** involves the conversion of indicators and/or variables to a comparable form, ensuring commensurability of data.

6. **Weighting** entails the determination of a weighting system in order to aggregate sub-indicators and/or variables, according to prioritised issues or statistically determined loads.

7. **Aggregation** refers to the grouping of indicators according to the underlying conceptual framework.

8. **Robustness and sensitivity analysis** is conducted to assess the robustness of the composite index with regard to the underlying assumptions made in the construction of the index, as well as the ‘sensitivity’ to changes in such assumptions.

9. **Establish links to other variables** providing an opportunity to make comparisons to other indicators and, where possible, verify and validate certain assumptions and choices made during indicator development.

10. Develop visually appealing and user-friendly tools towards enhancing **visualisation.** This step is also key in ensuring that indicators are well received by their target audience. Findings should therefore be presented in a simple and transparent manner, and results should be displayed so as to elicit the desired responses.

Given the time and resource limitations faced by De Carvalho (2007), it was not possible to undertake such a comprehensive exercise as proposed by Nardo *et al.*, however all steps were addressed, albeit in the order and to the degree that was suitable for the research.

Through a close examination of the urban water cycle a process model was developed which addresses the multi-dimensionality of sustainability and urban water systems (De Carvalho, 2007). This unique model combined the ideas of Lundin & Morrison (2002) and Nardo *et al*. (2005) and was the foundation of the development of the sustainability index (SI). The final process model, shown in Figure 2.7, combined qualities of the iterative procedure for assessing environmental sustainability presented by Lundin & Morrison (2002) with the steps recommended by Nardo *et al*. (2005) and the ideas on the systems approach discussed by Robèrt *et al.* (2002).

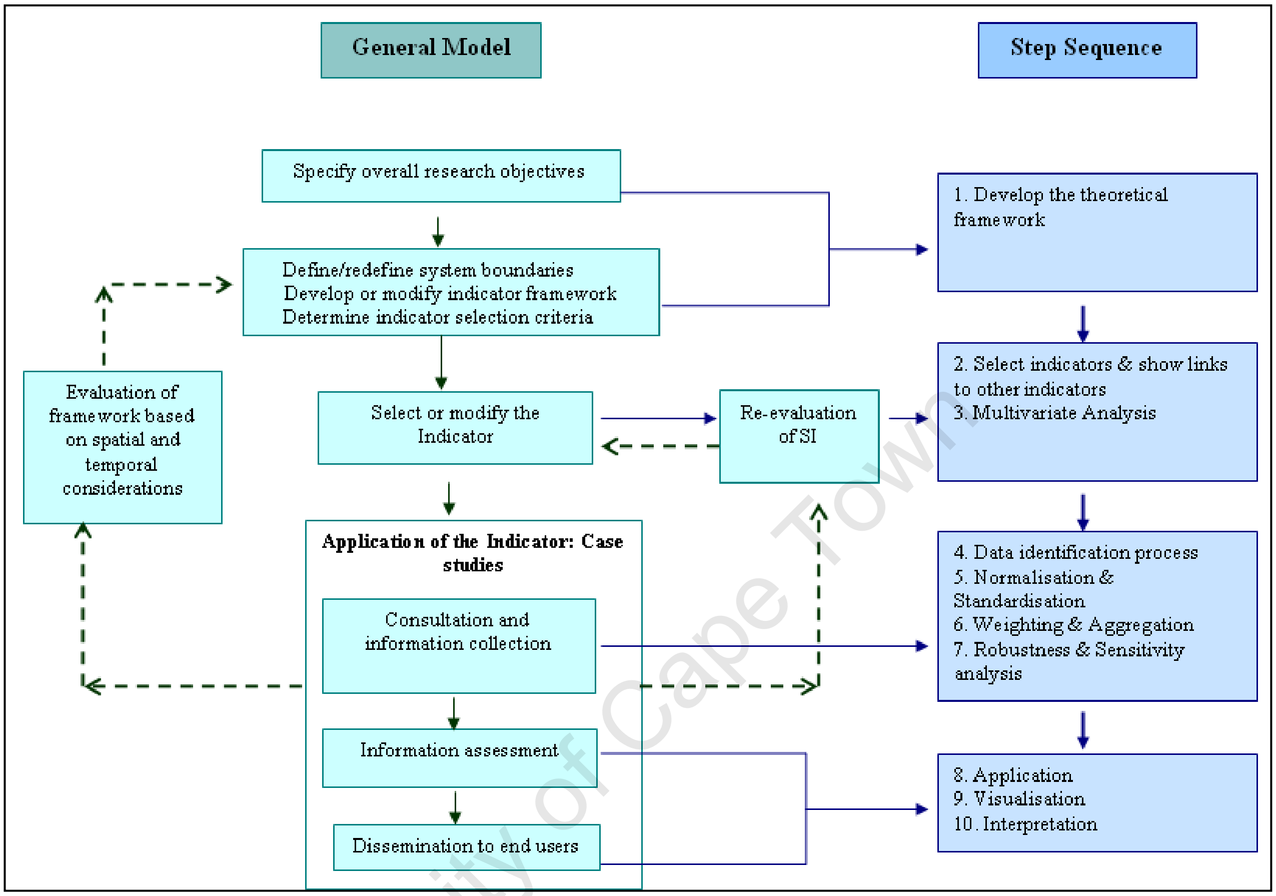

Figure 2.7: Stepwise approach to SI development (De Carvalho, 2007)

The final sustainability index as developed by De Carvalho (2007) consists of five components, which disaggregate into 20 indicators and ultimately into 64 variables. A detailed description of this SI is given in Chapter 4 and further explanation of the SI indicators and variables is given in Appendix A and D. Although the index does not measure sustainability directly it reflects the state of the overall components of IUWM which are thought to bring about a more sustainable society. It is for this reason that this index and other similar indicator sets are so subjective and need to be rigorously tested, discussed and debated among people from a range of specialist disciplines. De Carvalho (2007) expanded the index from the traditional three components of the triple bottom line to a set of five components: environmental, social, economic, institutional and political. The addition of institutional and political performance indicators resulted in a more balanced foundation upon which the sustainability assessment could take place. Figure 2.8 shows the structure of the SI.

5 components → 20 indicators → 64 variables → SI Score

Figure 2.8: The SI structure

The SI undertakes the aggregation of multiple and diverse variables, and it is often the case that variables are measured and represented in different units. Therefore, in order to compile such a complex indicator De Carvalho (2007) recognised the need to standardise the data according to a set and comparable frame of reference. There were a number of normalisation techniques considered for the SI from the work of Nardo *et al*. (2005), but ultimately one technique was employed, keeping in mind the need for clarity and simplicity. It was therefore resolved that the indicator conversion should employ a categorical scale normalisation approach, where all indicators were to be scored on a 0 – 5 scale. The categorical scale scores were assigned to the individual variables of the SI and, depending on the variable, were either quantitative, a score from 0 - 5, or qualitative, assessing on the basis of good, adequate, or poor for example.

Weighting systems were developed for the SI by De Carvalho (2007) during the index development process. The weights served to emphasise issues of particular concern. Those issues which needed to be highlighted were be given higher weightings and hence greater importance in the final index score. The process of determining and applying different weightings to verify the modifications in the results were done with the use of two weighting systems namely neutral and subjective weighting (De Carvalho, 2007). For the neutral weighting system, the first method used equal and balanced weighting where all the variables within the sub-indicators were equally weighted, and all sub-indicators within component categories as well as components making up the index were also equally weighted. The second method in the neutral weighting is that of equal and unbalanced weighting where sub-indicators with the highest number of variables received higher overall scores. For subjective weighting system, five sets of weightings were developed in line with the five dimensions of sustainability represented in the index. The SI for a particular area, *i*, (SI_i) is the sum of all the weighted components.

When applying the SI to a selected study area, a Microsoft Excel Workbook is used to input the gathered data and calculate sustainability performance scores for each component. Ultimately one final SI performance result as given in a percentage (%) and is calculated by averaging the five component results. The Excel Workbook was designed in such a way that the higher the score for an individual variable, indicator and component the better the study area performs towards sustainability. The single final SI result is but a 'snapshot' of the 'health and vitality' of the IUWM system in the study area and not a definite representation. Therefore, the final assessment of a study area demands further exploration of the contributing component and indicator scores (De Carvalho *et al.*, 2009).

2.8 Conclusion

To conclude, this chapter has presented literature on IUWM and showed how integrated management is a possible solution to the present water provision challenges faced by most cities in

Africa. The approach proposes a new way of viewing service delivery as a system rather than in isolated sectors. In order for IUWM to be successful there needs to be adequate planning, political buy-in and public involvement. With this, sustainable management of water resources can be achieved. The following chapter presents the method undertaken in applying the SI to case study areas and using this additional knowledge to modify and evaluate the strength and usability of the index.

3. Methods

3.1 Introduction

The literature review has introduced and clarified the meaning of Integrated Urban Water Management (IUWM) and has described examples of indicators used to measure sustainability. A particular focus was given to the explanation of the development and preliminary use of the Sustainability Index (SI) for IUWM. The core of this research lies in improving the SI and this chapter will outline the methods that have been used to evaluate the effectiveness of the index in measuring the sustainability of IUWM in a South African context.

In designing the process for this research, questions were considered to guide the formulation of the methods chosen and used. Stated below are the key questions and assumptions that underpin the research design.

3.1.1 Key questions

- Can the SI be improved to make it more effective tool for measuring sustainability of IUWM in a South African context?
- Can an index such as the SI reliably measure the sustainability of urban water management in South African cities?
- Do the results obtained from the SI reflect the true condition of water management systems in South African cities?
- Is the index practical and easily understandable in its application for municipality officials and other target audiences?

3.1.2 Assumption

- A negative or low SI result should cause action in the municipalities responsible for water management; this inherently assumes that the municipality has adopted the concept of IUWM.

In order to address the key questions of this research, the SI as developed by De Carvalho (2007) was applied to two study areas namely, East London and Port Elizabeth in order to gain a better understanding of its practicality and effectiveness. Following this, an in-depth assessment and evaluation of the SI was done. The index was modified with the guidance of recommendations given by previous users of the index and the findings from the preliminary SI assessment in this research. The index was developed by De Carvalho (2007) was meant for applicability in two different contexts i.e. Mozambique and South Africa. For this research only South African cities were studied, therefore some of the indicators and variables in the SI were altered. The revised SI was applied again to the same study areas and the results obtained were discussed with reference to information gathered from the visits to the study areas. The research method explained in detail in the following sections helped to address the key questions of this research.

3.2 Case study selection

The study was largely at a desktop level with most of the information coming from widely published sources (in print or internet), such as Census data (and General Household Surveys), Annual Reports, Water Services Development Plans (WSDPs) and water quality data from municipal laboratories. However, it was acknowledged that some of the qualitative data needed for the index required the use of secondary sources, such as, engaging with officials from local and central government. In addition, 'ground-truthing' was done during site visits to the selected cities of East London and Port Elizabeth to validate the data gathered and fill in the gaps where data was missing.

3.2.1 Data availability

The case study cities were selected from the nine member cities of the South African Cities Network (SACN). SACN is a collaboration of South African cities and partners that encourages the exchange of information, experience and best practices on urban development and city management (SACN, 2006). SACN is an initiative of the Minister for Provincial and Local Government and the nine municipalities. It is in partnership with the South African Local Government Association (SALGA) and government departments (SACN, 2006). The nine member cities are:

- Buffalo City Municipality
- City of Cape Town
- Ekurhuleni Metropolitan Municipality
- eThekwini Municipality
- City of Johannesburg
- Mangaung Local Municipality
- Nelson Mandela Metropolitan Municipality
- City of Tshwane

SACN member cities were selected as potential case studies for this research because the network promotes the sharing of information by way of their sustainable cities theme. The SACN also reports annually on their member cities with the use of specific indicators and publishes the information in 'State of Cities' reports. Selecting study areas for this research from the Network thus provided access to readily available data. Additionally, SACN seeks to improve management of cities and ultimately promotes sustainable development, thereby having a common goal with this research. In assessing the availability of data relating to the SI in the SACN cities, the researcher accessed the SACN website and each member municipality website. In addition, online and printed documents relating to water services, such as Integrated Development Plans and Water Services Development Plans were sought in an effort to evaluate the accessibility of data.

3.2.2 Selection of case study cities

In order to assess the effectiveness of the SI, two case studies were selected from the SACN cities. The main deciding factors in the selection of the case studies were the time and resources available to the researcher, data availability, and location of the municipality. Moreover, the presence of existing contacts in the municipality was another factor in selecting the case study cities. To avoid the difficulty of obtaining data for such a wide range and number of variables, case study selection was restricted by the probability of acquiring information in the limited time available for the completion of the thesis and the closeness of the cities to each other. As such, the cities of East London (Buffalo City Municipality) and Port Elizabeth (Nelson Mandela Metropolitan Municipality) were chosen. Although the researcher was based in Cape Town, the city was not chosen because Cape Town has already been used by another researcher as a case study for the same SI.

3.3 Gathering and applying SI input data

3.3.1 Step-wise data acquisition process

In the case of research such as this, where information covering interdisciplinary areas is required, it is often difficult to obtain reliable, quality data that is complete and frequently updated. De Carvalho's experience with regard to the complex nature and problems faced in data collection resulted in the development of a 'step-wise' data acquisition process to guide future researchers and users of the sustainability index through the process of establishing and employing appropriate data for the core variables. The 5-step approach, which was used in this research, addresses the raw data requirements prior to normalization and standardization. The step-wise data acquisition process comprises the following (De Carvalho, 2007):

1. Establish the credentials (reliability and credibility of source) of potential data sources and/or producers of data.
2. Obtain and screen data sources for reliable, quality data.
3. Where insufficient original data exists, employ data imputation techniques to 'fill in the blanks'
4. Where imputation is not possible, make informed guess estimates based on expert input and personal experience.
5. If steps 2-4 fail, then attribute a 0 score for the particular case or eliminate the variable from the index.

Step 1: Establish credentials

A contact list was formed of relevant authorities and consultants with knowledge of the two case-study municipalities. Considering that the provision and management of water services in South Africa is often the responsibility of municipalities and government institutions, establishing information on possible data sources and authors of data first involved establishing contact with these authorities. Contacts made through this task were then used to point to further reliable sources in the various fields concerned.

Step 2: Data acquisition and screening process

This step involved telephonic and electronic-mail consultation with municipality and government institutions to facilitate the information sharing process. Given time limitations, data gathering was conducted in a strategic manner so as to gather as much information as possible. The data acquisition process was done mainly via desktop study. Reports relating to water services development and management were downloaded from the internet and information provided by the government officials and consultants was used. Telephone interviews were set up and emails listing the information required were sent out to the relevant authorities requesting data for the preliminary assessment of the selected cities.

A screening process was performed so as to determine which of the data gathered conformed to the indicator requirements. The screening process ensuring data quality as discussed by Nardo *et al.* (2005) is outlined below. All data was checked to see that it conformed to the following:

a) Relevance to which the data fulfills its intended purpose

b) Accuracy to which the data approximates 'real' values

c) Reliability/credibility of the source or producer of the data and whether this source is either officially accredited or internationally recognized

d) The time lapse between the time of measurement or the time between the event and the time the data is made available

e) Ease of access and the appropriateness of the form of distribution

f) Level of understanding for users so as to enable them to make appropriate use of the data

g) The degree of logic and consistency in data products so as to provide clarity of use

Step 3: Dealing with missing data

The index required the collection of data from multidisciplinary areas from a wide range of sources, therefore it was fair to predict relative difficulty in acquiring complete information for all the variables. When gaps in the data were encountered or where the available data failed to directly answer the question posed by the indicator, one of two options were chosen. To begin with, if the data available did not directly answer the question posed by the sub-indicators then variables were either re-worded or proxies were used (De Carvalho, 2007). In cases where data was completely missing, methods of 'filling the gaps' were devised.

One main technique was used if needed to 'fill the gaps' where data is missing. This method is called *'hot deck imputation'* and involves the use of data from similar units or cases (in this scenario, other municipalities) to fill blanks where data is missing (Nardo *et al.*, 2005). For example, cities with similar physical and socio-economic conditions can be used to replace each other's data requirements when information is available for one but not for the other. However, this technique negatively affects the accuracy of the results and should only be used when all data collection methods have been exhausted.

<u>Step 4: Making informed guesses</u>

The next step involved making informed guesses where data gaps could neither be substituted nor inferred. This was done through an extensive review of the literature or through consulting experts in the field. In addition the experience and knowledge of various members of the Urban Water Management Group working on this project was used to make informed guesses regarding the missing data.

<u>Step 5: Exclusion of variables or zeroing variable scores</u>

The last step involved choosing whether to exclude a variable or attribute a zero score to the particular variable lacking information. This was done on a variable-to-variable basis, because the overall importance of variables differs depending on their relevance to the setting and general index structure. Exclusion was done to reduce the bias for or against the outcome of the case study with or without data for that particular variable.

3.3.2 Standardizing the data

After gathering the data for the selected cities and recording the relevant information, the data was standardized. The process of standardization is conducted because the SI combines multiple and diverse variables which are often measured and represented in incompatible units. The normalization technique chosen for this research by the developers of the index is the '*categorical scale'* (De Carvalho, 2007).

With this approach, scores are assigned to individual indicators or variables. These categorical scores can be either quantitative, a score from 0-100, or qualitative, assessing on the basis of good, adequate or poor, for example. This approach gives an idea of absolute performances but depending on the scale chosen, can obscure significant differences across variables and within indicators. Variations might not be significant in terms of the overall score but may become problematic if these produce a change in the final rankings (De Carvalho, 2007).

It was resolved by developers of the index that all indicators were to be scored on a 0-5 scale. The scoring from 0-5 is fixed, however the endpoints vary from variable to variable (De Carvalho, 2007). A larger scale, say 0-100 was not adopted because the reliability of the data itself is questionable, therefore this would not have provided any real advantages in this research. Additionally, a 0-10 scale was not adopted because it would create difficulty in assigning 10 different categories for some of the qualitative data used in the index. As a result, the 0-5 scale was seen as the best option. Most of the categorical scales were selected on the basis of pre-established reference points, standards or rules, i.e. wastewater quality criteria or guidelines provided by the World Health Organization and others (De Carvalho, 2007).

3.4 Data Analysis

3.4.1 Preliminary assessment of selected cities and indicator assessment

After the data was collected, screened and standardized, a preliminary assessment of the case study cities using the SI was carried out. Initially, the index was run as it was without any modifications to it. The performance of the two cities was commented on, as well as the usability and effectiveness of the SI itself.

The SI Excel Workbook which was developed by De Carvalho (2007) using a Microsoft Office program uses Excel formulas to calculate the final SI result. The workbook was used to calculate the sustainability performance scores of East London and Port Elizabeth. The various weighting schemes developed by De Carvalho (2007) were also applied. The results are presented and discussed in Chapter 6 and in Appendix H and I of this thesis and are then compared to the modified SI.

3.4.2 Site visits

Site visits were arranged in order to validate the data gathered and to collect any data that was missing. In addition these site visits helped to compare and contrast the initial results obtained during the preliminary assessment and the actual situation 'on the ground' of these municipalities. Travelling to the cities allowed a more in depth study of the management and sustainability of the water services in each city. Interviews were conducted with municipal officials in water services as well as consultants working in water management in the city. Ultimately, the site visits helped to refine the data gathered from desktop level methods and to gain a better understanding of the system.

3.5 Modifying and evaluating the Sustainability Index for IUWM

Changes to the SI were guided by recommendations given by De Carvalho (2007) and literature studied on developing good sustainability indicators. A full explanation of the index assessment and modification is given in Chapter 4. Both the SI (De Carvalho, 2007) and the revised SI (2009) devised in this study were evaluated using an 'evaluation criteria matrix' adapted from work by Graymore *et al.* (2008). The two variations of the SI were also evaluated using a set of predetermined evaluation questions set by Singh *et al.* (2008) and the United Nations (2008).

3.6 Displaying and discussing results of the SI

The literature review and case study analysis formed the platform upon which the SI could be discussed and assessed. The discussion presented in Chapter 6 of this thesis highlights issues encountered with the concepts relating to the sustainability of IUWM in the two study areas. The evaluation of the SI was carried out systematically by going through the framework, structure and the resulting indicators of the SI. An attempt was made to understand what each indicator is measuring and how it relates to the sustainability of urban water management.

3.7 Making conclusions and recommendations

The final phase of this study involved the synthesis of all the information presented in the thesis into a list of conclusions and recommendations. Recommendations were made for both the case study areas and for further research and improvement of the SI.

4. Evaluating and modifying the Sustainability Index for IUWM

4.1 A review of the Sustainability Index 2007

The SI as developed by De Carvalho (2007) comprises five components, namely; social security, economic performance, environmental performance, political support and institutional capacity. It is further disaggregated into 20 indicators and ultimately into 64 variables. Some of the variables have sub-variables which are grouped and counted as a single parameter. Its structure is shown in Table 4.1. The strength of the SI 2007 is that it addresses the various areas of sustainable development, however it has been noted by previous researchers (De Carvalho, 2007; Hotchkiss, 2008; Makgalemele, 2008) that the index is too data intensive and time consuming when applying it to most cities. As a result, the objective of this thesis was to evaluate and modify the SI and make it a more effective tool for measuring sustainability in IUWM. This chapter explains how the SI developed by De Carvalho (which will be referred to as SI 2007) was adjusted, giving reasons for the various changes. The assessment and modification of the SI will result in a revised SI which will be referred to as SI 2009.

Table 4.1: Sustainability Index 2007 structure (De Carvalho, 2007)

Component (5)	Indicator (20)	Variable (64)
1. Social security and cultural acceptability (Social fairness and equitable resource distribution)	1. Access to water supply	1.1 Total collection time
		1.2 Gender bias
		1.3 Conflict over water sources
		1.4 % with access to protected water
	2. Access and use of sanitation facilities	2.1 No. people per sanitation facility
		2.2 Safety of use and safety to access facilities
		2.3 Cultural and social acceptability (type, odour issues)
	3. Levels of Service (LOS)	3.1 Water supply
		3.2 Sanitation
		3.3 Drainage
		3.4 Waste collection
	4. Vulnerability to disasters	4.1 Susceptibility to natural disasters
		4.1.1 Dolines and sinkholes
		4.1.2 Earthquakes
		4.1.3 Droughts
		4.1.4 Tornados
		4.1.5 Cyclones & floods
		4.1.6 Tsunamis or shock waves
		4.1.7 Fires
		4.2 Risk Management and disaster mitigation
	5. Health (morbidity and mortality)	5.1 Under 5 mortality rate
		5.2 Malaria-related mortality rate
		5.3 Reported cases intestinal & infectious diseases/1000
		5.4 HIV/AIDS prevalence
	6. Education and awareness	6.1 Level of dissemination (various forms of advertising accessible to all income groups)
		6.2 Level of stakeholders consultation and public participation

Table 4.1: Sustainability Index 2007 structure (continued)

Component	Indicator	Variable
2. Economic (Economically sound: economic growth and cost-returns)	7. Capacity (to pay or access services)	7.1 % people with secondary education
		7.2 Unemployment rate
		7.3 Income levels
		7.4 No. of days per year taken off work due to water related diseases (Loss of income due to sickness)
		7.5 Min/Basic water tariff
	8. Cost Recovery	8.1 % users paying for water
		8.2 % of unaccounted for water (UFW)
		8.3 % of free basic water (FBW)
	9. Investment levels	9.1 % budget increase for water supply
		9.2 % budget increase for sanitation
		9.3 % of budget increase for O&M
		9.4 Sources of investment
3. Environmental performance (Environmental protection and preservation of ecological systems)	10. Fresh water Resources	10.1 Per capita water availability (l/capita/day)
		10.2 Reliability or variability
		10.3 Water quality at source
	11. Sustainability/ Feasibility of water sources	11.1 Sustainability of source
		11.1.1 Local Groundwater
		11.1.2 Rainwater
		11.1.3 Local surface water
		11.1.4 Imported groundwater
		11.1.5 Stormwater
		11.1.6 Greywater
		11.1.7 Imported surface water
		11.1.8 Brackish water
		11.1.9 Treated effluent (wastewater)
		11.1.10 Salt water
	12. Use (resource distribution per sector)	12.1 Domestic
		12.2 Industrial
		12.3 Agricultural and livestock
		12.4 Maintenance of ecosystems
	13. Wastewater management	13.1 Effluent quantity
		13.2 Effluent quality
	14. Stormwater management	14.1 Effluent quantity
		14.2 Effluent quality
	15. Compatibility of water system with the surrounding environment	15.1 Close to solid waste dump or landfill site
	16. Compatibility of sanitation systems with the surrounding environment	16.1 Located on flood prone area
		16.2 Steepness
		16.3 Depth to groundwater table
		16.4 Soil permeability
		16.5 Ground stability
	17. Environmental stresses	17.1 % of polluted water sources
		17.2 % of total area identified as severely water stressed

Table 4.1: Sustainability Index 2007 structure (continued)

Component	Indicator	Variable
4. Political support and international stewardship	18. Governance	18.1 Democracy and representation
		18.2 Measure of corruption
		18.3 Defined roles and responsibilities
	19. Compliance with policy	19.1 Government policies
		19.2 MDGs
5. Institutional capacity and technological progress	20. Institutional and technical capacity	20.1 Adoption of IWRM approach
		20.2 No. of water management institutions
		20.3 Adoption of alternative water supply technologies
		20.4 Adoption of 'sustainable' sanitation
		20.5 Corresponding education levels for O&M
		20.6 Monitoring capability (including issues of data quality)
		20.7 Reliability of service provision
		20.8 Failure in service delivery due to dependence on other sectors (electricity, transport etc)

4.2 Guidelines for the modification of the SI 2007

Changes to the SI 2007 were guided by recommendations given by De Carvalho (2007) (see Appendix A) and the literature on developing effective sustainability indicators. In particular, the International Institute for Sustainable Development (IISD), one of the world's leading NGOs supporting the development of indicators of sustainable development, informed the modification process (Miller, 2007). In 2000, the IISD offered the following guidelines to developing an effective indicator (IISD, 2000):

- **Availability of affordable data**
  The indicator should use good quality data which is available at a reasonable cost.
- **Simplicity**
  The information gathered from the indicator must be presented in an easily understandable and appealing way for the target audience. Complex issues and calculations should eventually yield clearly presentable information that the public understands.
- **Policy relevance**
  The indicator should be associated with one or several issues around which key policies are formulated. This is because sustainability indicators are intended for audiences to improve the outcome of decision-making on levels ranging from individuals to the entire biosphere. Therefore, unless the indicator can be linked by readers to critical decisions and policies, it is unlikely to motivate action.
- **Validity**
  The data used in the index needs to have been collected using scientifically defensible measurement techniques. This methodological rigor is needed to make the data credible for both experts and the general public.
- **Time-series data**

The indicator should use time-series data which reflects the trend of the indicator over time.

- **Reliability**
  The same result should be obtained if two or more measurements are made of the same indicator. Ideally two different researchers should arrive at the same conclusions using the same indicator.

In a work programme on indicators, the United Nations defined the purpose of sustainable development indicators as "tools for guiding political decision-making towards sustainable development, improving information and data collection, and enabling a comparative analysis of the state of and progress towards sustainable development" (UNDPCSD, 1995). According to UNDPCSD in order to properly serve these purposes, sustainability indicators need to be:

- based on a sound scientific basis and widely acknowledged by the scientific community
- relevant and cover crucial aspects of sustainable development
- transparent in their selection, calculation and meaning must be obvious even to non-experts
- quantifiable, i.e. they should be based as far as possible - but not exclusively - on existing data and/or on data which is easy to gather and to update
- limited in number according to the purposes they are being used for.

One problem identified by previous users and developers of the index was that the SI comprised too many indicators and variables. As such, one of the goals in modifying the SI was to reduce the number of indicators and variables thereby making it more user-friendly and less time consuming to apply. This reduction was also done to avoid repetition and improve the accuracy and robustness of the SI. The revision of the SI required the results of the SI 2007 and modified SI to be similar. This would ensure that the integrity of the SI is maintained in an index that has fewer data requirements. The overarching guideline was that indicators and variables which truly measure sustainability and not some mere relationship we re selected for the revised SI. Where the data was hard to find or simply not recorded, the indicator or variable was removed or replaced with a similar indicator with more readily available data. Where possible, measurements were converted to a percentage rather than real figures for comparison sake. An in-depth description of the modification process is given in the following section.

4.3 Assessing the overall SI structure and weighting system

A preliminary assessment of the SI 2007 was done by the use of the case study cities, East London and Port Elizabeth. The problems identified in its use and effectiveness were noted and thereafter informed the revision process.

4.3.1 Overall SI structure

The SI is calculated using a composite index approach. This approach has been used in index initiatives such as the HDI and the ESI. The decomposition of the SI into components, sub-indicators and variables is shown in Figure 4.1.

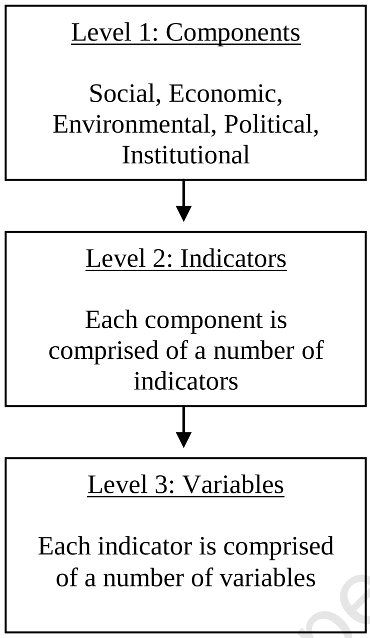

Figure 4.1 Levels in the Sustainability Index

The SI 2007 consists of five main components. The five components were chosen from a review of literature on sustainable development and its different definitions. Initially the triple bottom line perspective on sustainability was looked at highlighting the social, environmental and economic dimensions; however the lack of an institutional or political dimension demanded revision of this perspective. In favour of revising the triple bottom line approach, the work of Valentin & Spangenberg (2000) on the 'Prism of Sustainability' was considered. The 'prism' is composed of four dimensions of sustainability, namely: social, economic, environmental and institutional. In this model the institutional dimension represents both political and administrative aspects. However it was noted by De Carvalho (2007) that the political and administrative aspects contribute significantly to the success or failure of integrated management independently of one another, and as such merit a categorical separation. This view of five components of sustainability is maintained in the revised SI as all five components are seen to be individually important with regard to integrated water management.

4.3.2 Weighting system

In the context of indicator development, weights often serve to emphasize issues of particular concern. The SI results were presented in a variety of weighting systems as adopted by De Carvalho (2007), namely; neutral weighting and subjective weighing. For neutral weighting, the first method used equal and balanced weighting where all the variables within the sub-indicators were equally weighted, and all sub-indicators within component categories as well as components making up the index were also equally weighted. The second method in the neutral weighting is that of equal and unbalanced weighting where sub-indicators with the highest number of variables received higher overall scores. For subjective weighting, five sets of weightings were developed in line with the five dimensions of sustainability represented in the index. The SI for a particular area (SI_i) is the sum of all the weighted components (Equation 4.1). Variables and sub-indicators are aggregated in the same manner as components. The standardized value of the respective component X_i is multiplied by the attributed weight, w_{xi}, to give a value on a scale of 0-5. For the SI, the formula is shown in Equation 4.2, accounting for all the components of sustainability:

$$SI_i = \frac{\sum_{i=1}^{N} w_{x,i} X_i}{\sum_{i=1}^{N} w_{x,i}} \tag{4.1}$$

$$SI_i = \frac{w_s S + w_e E + w_{ev} EV + w_p P + w_i I}{w_s + w_e + w_{ev} + w_p + w_i} \tag{4.2}$$

S - Social; E - Economic; EV - Environmental; P - Political; I - Institutional.

The symbols: w_s, w_e, w_{ev}, w_p, w_i, represent the weights for the five components mentioned above.

For the purpose of ensuring that different case studies are comparable, it is important that the weight allocations are set to a specific scheme. The SI will lose its usefulness if each user assigns his/her own weighting system. For simplicity the SI should ideally be made up of variables which hold equal worth in the construction of the indicators, indicators which hold equal worth in the construction of the components, and components which in turn hold equal worth in the construction of the final score. By ensuring that the results of the SI are transparent, a breakdown of the SI scores should clearly show the areas in which progress towards sustainability is being hindered without needing the weighting scheme to emphasise shortfalls.

In the preliminary SI 2007 assessment, data from East London and Port Elizabeth was used to compute the index and all these different weighting systems were applied. It was found that the overall SI value did not vary significantly as the maximum variation was 3%. The results obtained for both East London and Port Elizabeth for the various weighting systems are shown in Table 4.2. Therefore in the revised SI (SI 2009) the neutral weighting scheme of 'equal and balanced' was selected as the only scheme to be used.

Table 4.2 SI 2007 results for East London and Port Elizabeth using different weighting systems

SI weighting system	East London	Port Elizabeth
Equal and balanced	67%	68%
Social bias	66%	69%
Economic bias	65%	67%
Environmental bias	64%	65%
Political bias	67%	69%
Institutional bias	67%	69%
Maximum range	3%	4%

All five components were seen to have equal value in terms of attaining sustainable urban water management and having one weighting scheme simplified the SI. Appendix B provides an explanation of the aggregation system used for the indicators and variables Appendix C presents a detailed table that shows the ‘equal and balanced’ weighting scheme chosen for the SI 2009.

4.4 In-depth indicator and variable assessment

This section gives an in-depth assessment of the indicators and variables comprising the SI as developed by De Carvalho (2007) and explains how the SI was modified to produce a more effective index. In order to assist in the evaluation and modification of the indicators and variables used in the SI, a number of sustainability principles were drawn up for each of the five components. Most of these principles are based on ideas gained from Hill & Bowen (1996) as illustrated in Figure 4.2. It is important to understand that the institutional and political components of sustainability form the foundation upon which the other components can be built.

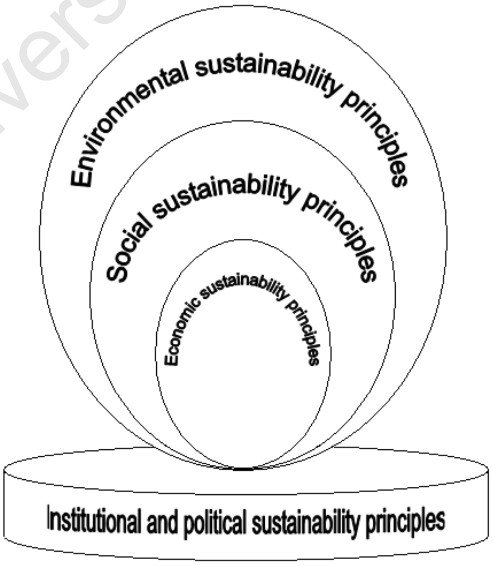

Figure 4.2: Embedded sustainability principles (Hill & Bowen, 1996)

4.4.1 Social Component

Hill & Bowen (1996) state that the overarching principle of social sustainability is for the quality of human lives be to continually improved. This can be achieved through the following principles:

- Ensure that basic needs such as safe water and sanitation are fulfilled
- Ensure that people are able to live with dignity in an environment which is safe and healthy
- People need to receive education and training which should lead to knowledge and skills which are both useful and edifying
- Equity should be strived for in all aspects of society; between genders, races, income groups and generations.

In order for the SI to be effective, the above principles should be reflected in the indicators. The social component of the SI 2007 consists of six indicators and 19 variables as shown in Table 4.3.

Table 4.3 Social component structure of SI 2007

Indicators	Variables
1. Access to water supply	1.1 Total collection time
	1.2 Gender bias
	1.3 Conflict over water sources
	1.4 % with access to protected water
2. Access and use of sanitation facilities	2.1 No. people per sanitation facility
	2.2 Safety of use and safety to access facilities
	2.3 Cultural and social acceptability (type, odour issues, visual and physical contact with excreta)
3. Levels of Service (LOS)	3.1 Water supply
	3.2 Sanitation
	3.3 Drainage
	3.4 Waste collection
4. Vulnerability to disasters	4.1 Susceptibility to natural disasters
	4.1.1 Dolines and sinkholes
	4.1.2 Earthquakes
	4.1.3 Droughts
	4.1.4 Tornados
	4.1.5 Cyclones & floods
	4.1.6 Tsunamis or shock waves
	4.1.7 Fires (impact of fires due to inadequate water supply)
	4.2 Risk Management and disaster mitigation
5. Health (morbidity and mortality)	5.1 Under 5 mortality rate
	5.2 Malaria-related mortality rate
	5.3 Reported cases intestinal and infectious diseases per 1000
	5.4 HIV/AIDS prevalence
6. Education and awareness	6.1 Level of dissemination (various forms of advertising accessible to all income groups)
	6.2 Level of stakeholders consultation and public participation

Although the social component in the SI 2007 does take into account the social sustainability principles of basic needs, safety, health and education, the component does fall short in some places and these are explained in detail below.

The problems faced with the indicators in this component relate mainly to the fact that when the index was developed by De Carvalho (2007) it was meant for applicability in two different contexts i.e. Mozambique and South Africa. For this research only South African cities were studied, therefore some of the indicators and variables were found to be insignificant in a South African context. The variable 'conflict over water sources' for example, does not play a major role in affecting urban water management in South Africa and was therefore removed from the index.

4.4.1.1 Basic needs

The social sustainability principle of 'ensuring that basic needs such as safe water and sanitation are fulfilled' is measured by the use of the indicator 'level of service' (LOS). One of the steps in moving towards some of the targets stipulated by the MDGs, is to ensure that at the very least, basic levels of services are provided (UNDP, 2005). In South Africa, services have conformed to tiers of service provision, for which income levels and ability to pay are the key factors. Slight changes were made to the LOS indicator to make it more appropriate in the South African context. The service levels for the SI 2009 are shown in Table 4.4.

Table 4.4: Description of Level of Service

	Water supply	Sanitation	Drainage	Waste collection
LOS1	Individual house connection	Conventional sewerage Vacuum sewerage Simplified sewerage	Conventional (primary) SUDS	Frequent & reliable (weekly)
LOS2	Roof tanks Yard tanks & taps	Septic tanks On-plot sanitation (improved)	Conventional (primary and secondary)	Regular but infrequent (once every 2 weeks)
LOS3	Standpipes	On-site communal facilities	Greywater management	Infrequent (one monthly)
LOS4	Communal standpipes	Bucket toilets	No formal drainage	No formal collection (>4 weeks)
LOS5	None	None	None	None

One problem found with the social component was that of repetition of data in the indicators and variables. For example in the SI 2007, variables such as the 'total collection time' and 'safety of use' are linked to the 'level of service' indicator for sanitation and water supply respectively. It was found the inclusion of these variable scores hardly affected the overall outcome. This is shown in Table 4.5 which shows the SI 2007 results for East London and Port Elizabeth with and without the variables linked to the 'level of service' (LOS) indicator (for all components). As a result of this finding the variables linked to 'access to water supply' and 'access and use of sanitation facilities' were removed from the index.

Table 4.5 SI performance difference for LOS variables

	SI 2007 performance with all variables	SI 2007 performance without those linked to LOS	Performance without 'access to water supply' and 'access and use of sanitation facilities'
East London	67%	65%	2%
Port Elizabeth	68%	67%	1%

4.4.1.2 Safety

The social sustainability principle of 'ensuring that people live with dignity in an environment which is safe and healthy' is addressed in the 'vulnerability to disasters' indicator. However, in order to simplify the SI the sub-variables for the 'susceptibility to disasters' variable (shown in Table 4.3) were combined into one weighted variable and not individual ones as in the SI 2007.

4.4.1.3 Health

It is important to consider health when discussing urban water management because there is a causational link between the two. There is scientific backing as to the diseases which result from poor water supply (quantity and quality) and inadequate sanitation (UNDP, 2005). In order to address the water supply and health relationship it is common to look at the most vulnerable groups who are worst affected by poor access to water i.e. children and those with a compromised immune system. 'Under 5 mortality' rate and 'HIV/AIDS prevalence' was seen to have the highest correlation with water supply and management according to work done by the UNDP and therefore these variables were kept in the index (UNDP, 2005). The variable 'malaria-related mortality rate' had a low impact on the SI result because South Africa is generally not a malaria affected region (HST, 2008). Malaria transmission in South Africa is seasonal and from 2001 to 2008 there was a sustained decrease in the number of nationally reported malaria cases and deaths. This is largely the result of a number of interventions, including the use of combination drug therapy and collaborative malaria control efforts (HST, 2008). Consequently this variable was removed from the index.

4.4.1.4 Education

The level of education is important when trying to achieve sustainable water management. The social sustainability principle concerning education is addressed by the SI indicator on 'education and awareness'. Although the SI 2007 does measure the 'level of dissemination' and 'level of stakeholder consultation' the variable for '% of people with secondary education' is placed in the economic component due to De Carvalho's opinion that education levels have more of a relationship with people's ability to pay for services. However, Hill & Bowen (1996) cite education as more of a social issue than an economic one. Therefore, the variable '% people with secondary education' was moved from the economic component to the social component keeping a similar aggregation system. Education is closely linked to social issues.

Overall the assessment of the social component showed that the SI 2007 did take into account most of the social sustainability principles and where it was lacking, changes were made as described above. The social component was also reduced in terms of the number of indicators and variables comprising it, making the index less data intensive. The resultant structure of the social component for the SI 2009 is shown in Table 4.6.

Table 4.6 Social component structure of SI 2009

Indicators	Variables for SI 2009
1. Levels of Service (LOS)	1.1 Water supply
	1.2 Sanitation
	1.3 Drainage
	1.4 Waste collection
2. Vulnerability to disasters	2.1 Susceptibility to natural disasters
	2.2 Risk Management and disaster mitigation
3. Health (morbidity and mortality)	3.1 Under 5 mortality rate
	3.2 HIV/AIDS prevalence
4. Education and awareness	4.1 % with secondary education
	4.2 Level of dissemination
	4.3 Level of stakeholders consultation and public participation

4.4.2 Economic Component

Economic systems of sustainability are seen as being rooted within the social and environmental systems (Hill & Bowen, 1996). With regard to urban water management, the overarching principle of economic sustainability is that financial resources should be managed in such a way so as to drive the principles of environmental and social sustainability. This can be achieved through the following principles:

- With regard to service provision, a balance should be achieved between sustainable cost recovery and the public's affordability level
- Financial investment should create an environment which promotes employment creation.
- Invest in sustainable technology
- Minimise all unnecessary costs such as UFW through water loss programmes and efficient management.

The economic component of the SI2007 comprises 3 indicators, namely: capacity of the public to pay for services, the authority's cost recovery, and the level of investment on water services and management. The 12 variables in the economic component are shown in Table 4.7.

Table 4.7 Economic component structure of SI 2007

Indicator	Variable
7. Capacity (to pay or access services)	7.1 % people with secondary education
	7.2 Unemployment rate
	7.3 Income levels
	7.4 No. of days per year taken off work due to sickness
	7.5 Min/Basic water tariff

Table 4.7 Economic component structure of SI 2007 (cont.)

Indicator	Variable
8. Cost Recovery	8.1 % users paying for water
	8.2 % of unaccounted for water (UFW)
	8.3 % of free basic water (FBW)
9. Investment levels	9.1 % budget increase for water supply
	9.2 % budget increase for sanitation
	9.3 % of budget increase for O&M
	9.4 Sources of investment

The three indicators adequately account for the economic sustainability principles mentioned previously; therefore the three indicators in the SI 2007 are maintained in the revised SI. However, the variables in the indicators needed some adjustments.

4.4.2.1 Capacity to pay

One way of achieving economic sustainability with regard to service provision, is to maintain a balance between sustainable cost recovery, affordability and the public's ability to pay. Accordingly, to measure economic sustainability one must determine people's capacity to pay for these services. One problem with the indicator of 'capacity to pay' in the SI 2007 was that it included variables which were not directly linked to people's ability to pay for services or variables that were better fit for a different component. For example, the variable '% of people with secondary education' was moved to the social component as explained earlier. The variable 'number of days per year taken off work due to water related diseases' is linked to the 'health' variable in the social component and was removed from the index because the data needed for it is not readily available. In addition, the 'basic water tariff' variable was also removed because the basic water tariff does not vary greatly amongst the South African cities and the variable was therefore seen to have minimal impact on the SI result. Ultimately, the variables 'unemployment rate' and 'income levels' were seen to be the best measure for 'capacity to pay'.

4.4.2.2 Cost recovery

A significant contributor to poor service provision is the lack of financial resources for expansion and operation. In the interest of self-sufficiency and sustainability, water services providers should aim for high cost recovery, provided it does not jeopardise social precepts. In South Africa, the problem of cost recovery is one of unacceptable resource wastage (in the form of unaccounted for water) combined with poor payment levels. Hence, the variables seen to best quantify an area's ability to sustainably recover service delivery costs are '% of users paying for water' and '% of unaccounted for water'. These variables are measured on a year on year basis. In an effort to reduce the variables comprising the SI thereby making it less data intensive, the variable '% of free basic water' was removed.

4.4.2.3 Investment in service delivery

In assessing the SI 2007 it was found that the variables in the 'investment levels' indicator adequately account for the indicator. Inadequate investments in water infrastructure and human capacity have proven to be one of the biggest constraints in efficient management of water resources and service delivery. Current policy in South Africa has stipulated that significant decentralisation of power to municipalities be undertaken; however, financially, municipalities continue to be largely dependent on both regional and local government. This condition threatens their long term sustainability (DWAF, 2003). The indicator 'investment levels' provides a measure of the annual growth in investments in water services infrastructure and illustrates whether there is continual progress. The work of De Carvalho (2007) was seen as sufficient for this particular indicator. The revised structure of the economic component for the SI 2009 is shown in Table 4.8.

Table 4.8 Economic component structure of SI 2009

Indicator	Variable
5. Capacity (to pay or access services)	5.1 Unemployment rate
	5.2 Income levels
6. Cost Recovery	6.1 % users paying for water
	6.2 % of unaccounted for water (UFW)
7. Investment levels	7.1 % budget increase for water supply
	7.2 % budget increase for sanitation
	7.3 Sources of investment

4.4.3 Environmental Component

The overarching principle regarding environmental sustainability is that the earth's natural systems should be able to continually restore and maintain themselves (Hill & Bowen, 1996). The following are principles which assist in achieving environmental sustainability with regard to water management:

- Ensuring that enough water resources are reserved for the maintenance and preservation of ecosystems
- Reduce the use of energy, materials and land within the water sector. These resources should only be used at the rate at which they can be replenished naturally
- Reduce water demand and minimise the waste returning to environment by reusing wastewater
- Minimise pollution of water
- Conserve biodiversity
- Minimise human interference of natural systems.

In order to adequately measure the environmental sustainability of urban water management in an area, the principles above need to be reflected in the indicators and variables of the component. The environmental component of the SI 2007 consists of 8 indicators and 20 variables as shown in Table 4.9.

Table 4.9 Environmental component structure of SI 2007

Indicator	Variable
10. Fresh water Resources	10.1 Per capita water availability (l/capita/day)
	10.2 Reliability or variability
	10.3 Water quality at source
11. Sustainability/ Feasibility of water sources	11.1 Sustainability of source
	11.1.1 Local Groundwater
	11.1.2 Rainwater
	11.1.3 Local surface water
	11.1.4 Imported groundwater
	11.1.5 Stormwater
	11.1.6 Greywater
	11.1.7 Imported surface water
	11.1.8 Brackish water
	11.1.9 Treated effluent (wastewater)
	11.1.10 Salt water
12. Use (resource distribution per sector)	12.1 Domestic
	12.2 Industrial
	12.3 Agricultural and livestock
	12.4 Maintenance of ecosystems
13. Wastewater management	13.1 Effluent quantity
	13.2 Effluent quality
14. Stormwater management	14.1 Effluent quantity
	14.2 Effluent quality
15. Compatibility of water system with the surrounding environment	15.1 Close to solid waste dump or landfill site
16. Compatibility of sanitation systems with the surrounding environment	16.1 Located on flood prone area
	16.2 Steepness
	16.3 Depth to groundwater table
	16.4 Soil permeability
	16.5 Ground stability
17. Environmental stresses	17.1 % of polluted water sources
	17.2 % of total area identified as severely water stressed

The environmental component of the SI 2007 was found to be the most difficult to compile data for during the preliminary assessment. Data for some of the indicators was not easy to source and often needed some form of calculation.

4.4.3.1 Freshwater resources

This indicator shows the availability of water based on the existing freshwater resources for a certain area. For the SI 2007 it is assessed on the basis of 'per capita availability', 'reliability and variability', as well as the 'quality of raw water' supplied. During the preliminary assessment it was found that data for the variable 'reliability or variability' is not recorded regularly and was therefore taken out of the index due to difficulties experienced in getting the required data. In the discussion of the SI 2009 results it was noted that the Water Scarcity Index which indicates the amount of water potentially available per person, may be more useful than the ‘per capita water availability’ indicator used in this research and should be investigated in future research.

4.4.3.2 Sustainability of water source

The sustainability of a water source is a complex indicator which has been greatly simplified for use in the SI 2007. The sustainability of a water source (ground water, surface water etc.) is dependent upon a number of factors, such as the type of water that is available for use, the fraction of the available source which is utilised, and the growth of water demand. For the revised SI, sub-categories for the variable ‘sustainability of source’ were combined so that the indicator would have one weighting thereby simplifying the index calculation.

4.4.3.3 River Health

The indicators relating to ‘compatibility of water and sanitation system with the surrounding environment’ were difficult to gather data for. Most of the data required (depth of water table, soil permeability and ground stability over the study area) can only be accurately obtained through extensive investigations and have thus proven difficult to obtain. Preliminary assessment of the study areas in this research used average data estimated from municipality geographical maps due to the fact that information for these variables was not readily available. The lack of data for these indicators led to the inclusion of the River Health Index which measures the ecological state of river ecosystems in the area. The RHI takes into account water quality and habitat state amongst other factors. The RHI was seen fit to replace the indicators that presented difficulties in data gathering because it factored in the various indicators into one reportable value. Data for the RHI is recorded in River Health Programme reports and in State of the Environment reports for the various municipalities in South Africa (RHP, 2005). Data for the RHI has not been done on an annual basis, therefore when applying the SI during a year where no results are available, the most recent data available should be used. Table 4.10 shows how the different categories of the RHI were ranked according to the SI structure.

Table 4.10 River Health Index classification for SI 2009

River Health Classification	Score
Natural	5
Good	4
Fair	3
Poor	2
Unacceptable	1
None	0

4.4.3.4 Resource distribution per sector

When measuring the environmental sustainability of an urban water management system, it is important to consider the resource distribution per sector. This is in line with the environmental sustainability principle of ensuring that enough water resources are reserved for the maintenance and preservation of ecosystems. In the SI 2007 the ‘resource distribution per sector’ indicator illustrates the water distribution per category of user. It highlights the areas which are either under or over-consuming and emphasises the need for balanced (not equal) distribution. The SI 2007 identified the four main sectors of water use; domestic, industrial, agricultural and ecosystem maintenance. For the revised SI these sectors were kept the same however the data input for the variables were all converted to a percentage value instead of an actual value because it was found that the 'use of resource' was usually reported in a percentage form. This would also help in making the indicator comparable between case studies.

4.4.3.5 Wastewater management

This indicator monitors the discharges of wastewater in terms of quantity, to the environment and proposes to monitor the potential detrimental effects. Following on standard guidelines, the variable 'effluent quantity' enables an assessment of the current wastewater management practices and in a sense indicates whether there is compliance. The effluent quantity is measured in l/person/day.

The revised structure of the environmental component for the SI 2009 is shown in Table 4.11.

Table 4.11 Environmental component structure of SI 2009

Indicator	Variable
8. Fresh water Resources	8.1 Per capita water availability
	8.2 Water quality at source
9. Sustainability/ Feasibility of water sources	9.1 Sustainability of source 9.2 River Health Index
10. Use (resource distribution per sector)	10.1 Domestic
	10.2 Industrial
	10.3 Agricultural and livestock
	10.4 Maintenance of ecosystems
11. Wastewater management	11.1 Effluent quantity

4.4.4 Political Component

In order to achieve sustainability, political systems need to set a foundation upon which environmental, social and economic sustainability can be effectively accomplished. This can be achieved through the following principles:

- A democratic system of governance should lay a good foundation for equality, a key precept of sustainability
- No corruption should occur
- Policies should be made which support the principles of sustainability
- Authorities should attempt to comply with policies and national sustainability goals.

The political component required the least amount of change with the number of indicators and variables remaining the same. The political component of the SI 2007 consists of 2 indicators and 5 variables, the details of which are shown in Table 4.12.

Table 4.12 Political component structure of SI 2007

Indicator	Variable
18. Governance	18.1 Democracy and representation
	18.2 Measure of corruption
	18.3 Defined roles and responsibilities
19. Compliance with policy	19.1 Government policies
	19.2 Millennium Development Goals

Although this component required the least amount of change in terms its indicator and variable composition, it was noted during the preliminary assessment of the study areas that the qualitative data for the 'governance' indicator was the hardest to get objective data for because the data used was gathered from interviews with municipal officials.

4.4.4.1 Governance

While developing the SI, De Carvalho (2007) recognized the need for competent, stable governance and comprehensive legislation in achieving sustainability in the water sector. The ideals of democracy and the precepts of sustainability are inherently connected. In the SI 2007 the three variables in the 'governance' indicator are democracy, corruption and definition of roles and responsibilities. These provide a basic measure of the level of support for the goals of sustainable development, towards the fulfilment of basic service provision; such as water and sanitation

4.4.4.2 Progress with meeting the MDGs

A measure of compliance with legislative directives and international development goals provides an indication of commitment to addressing the issues at hand. In the SI 2007 the indicator 'compliance with policy' attempted to measure a study area's compliance with government policies and legislation as well as its compliance with Millennium Development Goals. The data for these two variables were recorded in the 'level of service' indicators in the social component. This was seen as inappropriate because a study area's 'compliance with policy' should have its own value. As a result, for the SI 2009 the indicator 'compliance with policy' was changed to 'progress with meeting the MDGs' because data for MDGs is widely reported. The variables in the new indicator are, '% with access to protected water' and '% with access to adequate sanitation'. These two variables were taken from the social component of the SI 2007 and were appropriately placed in the 'progress with MDG targets' variable. Table 4.13 shows how the 'progress with meeting MDGs' was recorded for the SI 2009.

Table 4.13: Access to adequate water supply and sanitation

% with access to water supply	% with access to sanitation	Scores
>90%	>90%	5
90%-70%	90%-70%	4
69%-50%	69%-50%	3
49%-30%	49%-30%	2
29%-15%	29%-15%	1
<15%	<15%	0

The structure of the SI 2009 political component is shown in Table 4.14. With regard to the ‘governance’ indicator, it is suggested that for future research alternative data sources be used instead of interviews with municipal officials who find it difficult to be objective about democracy and corruption in their workplace.

Table 4.14 Political component structure of SI 2009

Indicator	Variable
12. Governance	12.1 Democracy and representation
	12.2 Measure of corruption
	12.3 Defined roles and responsibilities
13. Progress with meeting MDGs	13.1 % with access to protected water
	13.2 % with access to adequate sanitation

4.4.5 Institutional Component

Without a good institutional structure with sufficient technical capacity, progress towards sustainability cannot be achieved in current-day urban areas. With sufficient institutional and technical capacity, sustainability can be monitored and information can be gathered from year to year to ensure that progress is being made. The indicators and variables in the SI should reflect a study area’s institutional sustainability. Institutional sustainability can be achieved through the following principles:

- Efficient water management needs sufficient technical capacity
- Innovative ideas should be researched and investigated to achieve sustainability
- Authorities working in different management sectors and at different levels of governance should work together in achieving sustainability goals
- The public should be informed of issues regarding the sustainability of IUWM and actions being undertaken by the authorities through public participation.
- Authorities should monitor progress towards sustainability targets

The institutional component of the SI 2007 consists of 1 indicator and 8 variables, the details of which are shown in Table 4.15.

Table 4.15 Institutional component structure of SI 2007

Indicator	Variable
20. Institutional and technical capacity	20.1 Adoption of IWRM approach
	20.2 No. of water management institutions
	20.3 Adoption of alternative water supply technologies
	20.4 Adoption of ‘sustainable’ sanitation
	20.5 Corresponding education levels for O&M
	20.6 Monitoring capability (including issues of data quality)
	20.7 Reliability of service provision
	20.8 Failure in service delivery due to dependence on other sectors

Information required for the institutional component is mainly qualitative in nature and is reliant on information gathered from interviews. The variable ‘number of water management institutions’ was removed because most South African cities are managed by the local municipality and possibly one other private institution. The value does not vary greatly and therefore does not impact significantly on the overall SI result. ‘Corresponding education levels’ are not reported in readily available documents and interview information yields little new knowledge on this variable. The variable was therefore removed. The variable ‘failure in service delivery’ was seen as a repetition of the ‘reliability of service provision’ variable and therefore was excluded. The structure of the institutional component for the SI 2009 is shown in Table 4.16.

Table 4.16 Institutional component structure of SI 2009

Indicator	Variable
14. Institutional and technical capacity	14.1 Adoption of IWRM approach
	14.2 Adoption of alternative water supply technologies
	14.3 Adoption of ‘sustainable’ sanitation
	14.4 Monitoring capability (including issues of data quality)
	14.5 Reliability of service provision

4.4.6 The SI Excel workbook

After having adjusted the SI, the next step was to revise the SI Excel workbook which is used to calculate the SI results. Due to changes made in the structure of the index, a new workbook needed to be developed with new formulas for the indicators, variables and weighting system. The amended Excel workbook has a step by step instruction page to guide the user in applying the SI; this is shown in Appendix D. Moreover, the Excel workbook has a section for comparing the SI results with the results of established indexes such as the HDI. An additional section allows for an interpretation of the SI score through the use of a predetermined scale. Overall the amended SI Excel workbook is more user-friendly and interactive.

4.5 Description of the revised SI

In adjusting the SI it became apparent that sustainability in urban water management is a difficult concept to translate into measureable variables. Einstein (1924) best expresses this dilemma in the following quote:

> “*Not everything that counts can be counted and not everything that can be counted counts.”*

Nonetheless, for this thesis a final structure for the revised SI was decided on through knowledge gained from literature. The structure of the modified index is shown in Table 4.17. This index structure has the same number of components as that of De Carvalho (2007) but has a reduced number of indicators (14) and variables (38).

Table 4.17 Structure of modified Sustainability Index 2009

Components	Indicators	Variables
1. Social security	1. Levels of Service (LOS)	1.1 Water supply
		1.2 Sanitation
		1.3 Drainage
		1.4 Waste collection
	2. Vulnerability to disasters	2.1 Susceptibility to natural disasters
		2.2 Risk Management & disaster mitigation
	3. Health	3.1 Under 5 mortality rate
		3.2 HIV/AIDS prevalence
	4. Education and awareness	4.1 % of people with secondary education
		4.2 Level of stakeholders consultation
		4.3 Level of dissemination
2. Economic	5. Capacity (to pay or access services)	5.1 Unemployment rate
		5.2 Income levels
	6. Cost Recovery	6.1 % users paying for water
		6.2 % of unaccounted for water (UFW)
	7. Investment levels	7.1 % budget increase for water supply
		7.2 % budget increase for sanitation
		7.3 Sources of investment
3. Environmental performance	8. Fresh water Resources	8.1 Per capita water availability
		8.2 Water quality at source
	9.Sustainability/ Feasibility of water sources	9.1 Sustainability of source
		9.2 River Health Index
	10. Use (resource distribution per sector)	10.1 Domestic
		10.2 Industrial
		10.3 Agricultural and livestock
		10.4 Maintenance of ecosystems
	11. Wastewater management	11.1 Effluent quantity
4. Political support and international stewardship	12. Governance	12.1 Democracy and representation
		12.2 Measure of corruption
		12.3 Defined roles and responsibilities
	13. Progress with meeting the MDGs targets	13.1 % with access to protected water
		13.2 % with access to adequate sanitation
5. Institutional capacity and technological progress	14. Institutional capacity and technological progress	14.1 Adoption of IUWM approach
		14.2 Adoption of alternative water supply
		14.3 Adoption of ‘sustainable’ sanitation
		14.4 Monitoring capability
		14.5 Reliability of service provision

4.6 Evaluating the Sustainability Index for IUWM

Both the SI 2007 and the SI 2009 were evaluated using an evaluation criteria matrix and a set of predetermined questions relating to indicator development. The two evaluation techniques are explained in the following section. The results for the SI evaluations are given in Chapter 6.

4.6.1 Evaluation criteria matrix

An ‘evaluation criteria matrix’ was used to subjectively assess the effectiveness of the sustainability index for IUWM when applied at the city scale. The matrix was developed by Graymore *et al.* (2008) to compare and contrast the effectiveness of five different sustainability assessment methodologies at a regional scale. As part of their work the five indices (i.e. ecological footprint, wellbeing assessment, quality of life, ecosystem health, natural resource availability) were tested using South East Queensland as a case study. The criteria matrix used in this research is adapted from Graymore *et al.* (2008) and has been changed slightly to conform to the focus of the sustainability index for IUWM. The evaluation criteria matrix was selected as the evaluation technique for this research because it describes and evaluates the attributes of an effective indicator. In addition it describes the characteristics that make the index useful for promoting sustainable management and capacity building (Graymore *et al.*, 2008). It therefore assists in the evaluation of the effectiveness of the IUWM sustainability index. The matrix is comprised of three main evaluation factors which are sub-divided into criteria for further assessment as shown in Table 4.18.

Table 4.18 Evaluation criteria matrix

Evaluation Criteria
A. Overall effectiveness of sustainability assessment
1. Data availability and accessibility • Uses existing data • Data is locatable and accessible • Data collection is cost effective (money and time)
2. Assessment is easy to use • No complicated calculations • No specialist knowledge required (eg. matrices) • No specialist software required • Easy to follow method and easy to follow • Small indicator set (i.e. manageable data set <40 indicators) • Not time intensive (i.e. less than 3 months to complete)
B. Method
3. Assesses sustainability directly • Produces an overall sustainability score/index through aggregation of indicator data • Aggregation method is logical • Objective assessment of sustainability • Integrated assessment including relationships between indicators
4. Information not lost during aggregation of data • Indicator performance is reported

• Variable performance is reported • Overall system sustainability is reported
5. Transparency in method used to produce results • Method was clear and well documented • Easy to understand how final results were derived from indicator data • Simplifications and assumptions kept to minimum to reduce impact on results
C. Usefulness of results
6. Simplifies complexity of sustainability and facilitates communication to a range of audiences • Easy to understand and interpret what results mean for regional sustainability • Result can be described in a single page report card • Able to visually represent the results • Sustainability reported at a range of levels – Detailed indicator performance – Sub-system/dimension performance – Overall system sustainability
7. Usefulness of the sustainability assessment results • Time and data efficiency of assessment • For municipality officials – Sustainability reported at a range of levels – Relates to policy, strategic planning, decision making – Points out where management actions are needed – Targets or thresholds to measure against – Can be used to assess trends overtime

The following section explains how the ‘matrix point system’ assessed the effectiveness of the Sustainability Index. Each criterion dot point (•) was given a score of 1 if it met the criterion, 2 if it partially met the criterion or a 3 if it did not meet the criterion at all. If the dot point was not applicable to the point in question it was not included in the evaluation matrix for that criterion (Graymore *et al.*, 2008). The overall criterion score was dependent on whether all of the criteria's dot points were met. If one of the dot points was partially (or not) met, then the criterion was given a score of 2 (partially met). If the average of the dot points is closer to 3, then it was given a score of 3. Only if all the dot points were met was the criterion given a score of 1 (Graymore *et al.*, 2008). To be deemed an effective sustainability assessment indicator and a useful tool for municipality managers, the SI must achieve a score of 1 for each criteria set.

a) <u>Overall effectiveness of sustainability assessment</u>

The first set of criteria in the matrix refers to the effectiveness of the sustainability index. Criterion 1 is based on data availability and accessibility, since data availability affects the quality of the sustainability assessment produced. Criterion 2 evaluates how easy the sustainability index is to use, since ease of use should encourage uptake of the index (Graymore *et al.*, 2008).

b) Methods used by index

The second set of criteria examines methods used by the sustainability index. Criterion 3 addresses the objectivity of the method(s). For instance, does the aggregation method used produce an overall sustainability score/index? Was the assessment carried out objectively, without the need of the user to make judgments about variables? The need to be an integrated assessment, taking into account the relationships between the indicators used and their impact on sustainability, are also criteria for evaluating the SI as a whole. Criterion 4 evaluates the loss of important information during the aggregation process. Were the indicator, variables and overall system sustainability performance reported? This seeks to determine whether all the necessary information was included in the indicator. Criterion 5 looks at the transparency of the method. How clear and well documented was the method? How logical was the method? How transparent was the way the results were determined, what were the simplifications and assumptions, and how did they impact results? (Graymore *et al.*, 2008)

c) Usefulness of results

The final section of the matrix, including Criteria 6 and 7, address the general usefulness of the results for communication and potential end uses. Criterion 6 evaluates how easy the results are to communicate to a range of audiences. If the results are to be used by government officials to promote better management of water services, then they must be easy to understand and interpret. Criterion 7 addresses how useful the results are for municipality managers for strategic and sustainable planning and management. To be useful for municipality managers the method must be time and data efficient. It must also be able to specify where management actions are needed and use targets or thresholds to help managers gauge how the city is performing.

4.6.2 Evaluation questions

In addition to the evaluation criteria matrix, the researcher addressed a series of questions which helped to evaluate the effectiveness of the index. These questions gave a more in-depth evaluation of the two variations of the SI by asking questions that cannot necessarily be translated into a 'point' system. The questions are adapted from work done by Singh *et al.* (2008) and the United Nations (2008) in relation to indicator evaluation and are listed below.

a) Flexibility: How flexible is the index for allowing change, purpose, method and comparative application?

b) Relevance to MDGs and other global initiatives: To what extent does the index reflect progress made towards the achievement of the MDGs?

c) Weaknesses: What are the main weaknesses in and constraints to using the index?

d) Strengths: What are the main positive qualities of the index?

e) To what extent does the index reflect the socio-economic situation in the city?

f) What use is made of the index at different levels (community, municipality, national, regional and global)?

g) Is the index able to predict whether IUWM in a specific city is being practiced, and whether the urban water system can sustain itself?

4.7 Summary of chapter

In conclusion, this chapter began by describing the SI as developed by De Carvalho (2007). An explanation then followed of how the SI 2007 was modified with the guidance of recommendations given by De Carvalho (2007) and literature on developing good indicators. An in-depth indicator and variable assessment was described (results available in Chapter 6). The following chapter provides background information on the case studies that were used to test both the original and the modified SI.

5. Description of Study Cities

In order to test the SI, two case studies namely, East London and Port Elizabeth, were selected. Both cities are located in the Eastern Cape Province of South Africa. Reasons for choosing these cities were explained in Chapter 3. This chapter starts by describing the context in which the cities are located, i.e. Eastern Cape Province. It then provides a short descriptive summary on the status quo of these two cities, to help build a portrait of each city that will facilitate verification of the SI results.

5.1 Introduction to Eastern Cape Province

The Eastern Cape Province is located in southeastern South Africa. It is the second largest province in the country with an area of 16 958 km² representing 14% of South Africa's total area. The province is bordered by the Indian Ocean on the south and east and on the northwestern side by the southernmost extremities of the Drakensberg mountain range. It shares borders with the Provinces of Free State, Northern Cape, Western Cape, KwaZulu-Natal as well as the Kingdom of Lesotho. The Eastern Cape has a wealth of beauty and natural resources, with countless species of animals, birds, plants and insects protected in reserve areas, making it a popular destination for tourists (Statistics South Africa, 2006). The province is the third most populous province after KwaZulu-Natal and Gauteng and has a population density of 38 people per square kilometer. This is slightly more than the national average of 37 people per square kilometer (Statistics South Africa, 2006). Economic development in the Eastern Cape is extremely variable, from urban industrial manufacturing centres to underdeveloped former homeland areas of the Transkei and Ciskei. During 2002, the Eastern Cape produced only 7% of the national GDP (DWAF, 2003).

In 1999, the Municipal Demarcation Board declared the new municipal boundaries for the Eastern Cape. The province was divided into six district municipal councils and one metropolitan region, namely Nelson Mandela Metropolitan Municipality (NMMM). There are 38 local municipalities within six district municipalities (Statistics South Africa, 2006). East London and Port Elizabeth are the province's main centers of urban growth. Figure 5.1 shows the location of Eastern Cape in relation to other provinces in South Africa.

Figure 5.1: Provincial boundaries of South Africa (Statistics SA, 2008)

5.2 East London

5.2.1 Geographical profile

East London is located within the Buffalo City Municipality (BCM) covering an area of over 1100km^2 with an estimated population of 1.4 million (Statistics SA, 2008). East London is a concentrated city business centre, which was initially established as a river port. East London experiences an average annual rainfall of approximately 921mm. Temperatures range from 18-26°C in summer and 11-21°C in winter. Figure 5.2 shows a map of the Greater East London area.

5.2.2 Demographics and service provision

According to Statistics South Africa, the population of East London in 2007 was approximately 205 000 (Statistics SA, 2008). Water supply in East London is the responsibility of Buffalo City Municipality (BCM). As a Water Services Authority (WSA) and Water Services Provider (WSP), BCM has various obligations and responsibilities in terms of achieving efficient and adequate water services for the city of East London and other areas in the municipality.

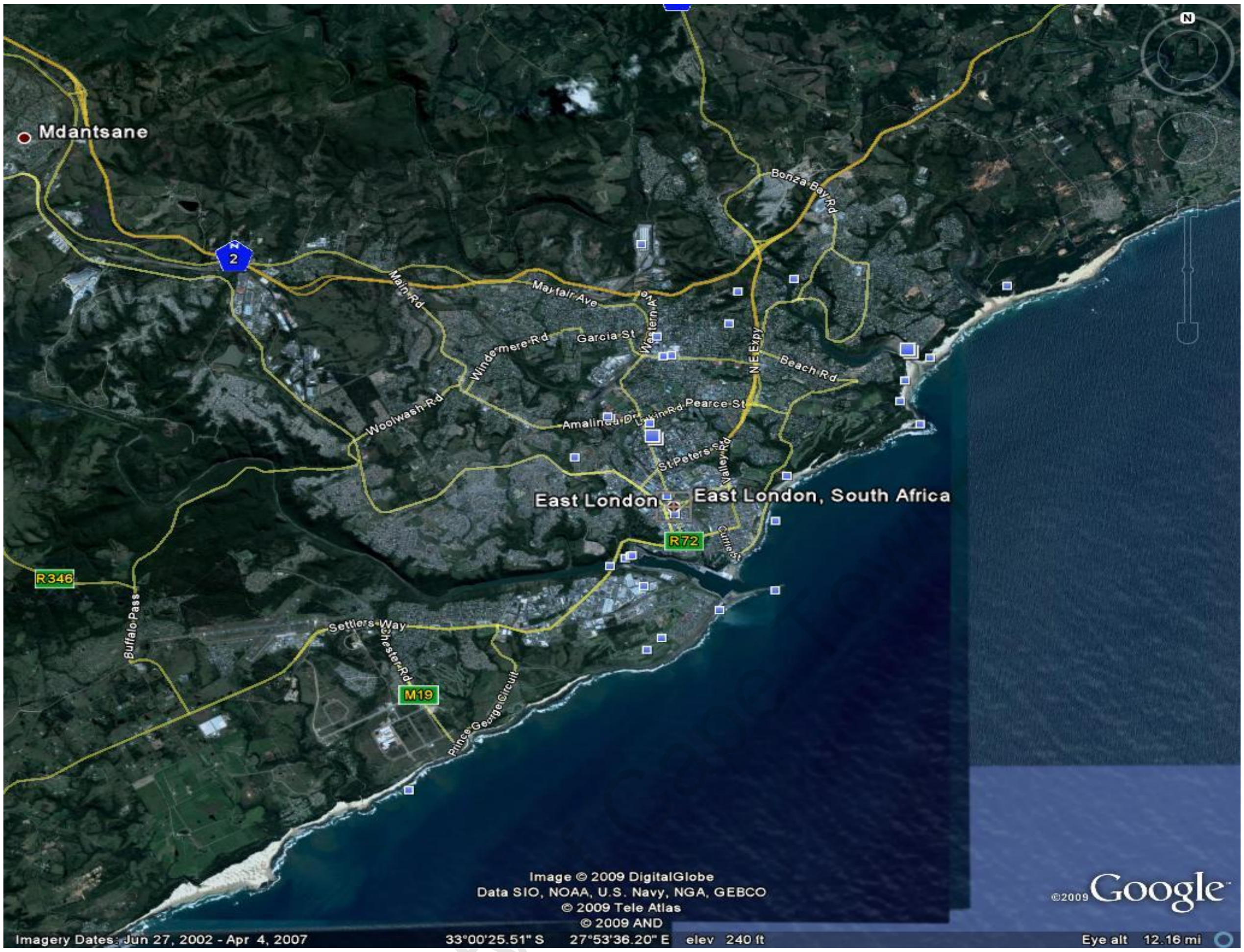

Fig 5.2: East London and other key urban centers in BCM (Google Earth, 2009)

Residents of East London get household water in a number of ways, including: piped directly into the house from the mains, from public standpipes, from boreholes, rainwater tanks, or from dams and rivers. The largest informal settlement in East London is Duncan Village with an estimated population of 60 000. The lack of basic services in this hilly area poses threats to the environment and the well-being of the residents.

Water for East London is sourced from the Bridle Drift Dam (main source), Rooikrantz Dam, Nahoon Dam , Laing and Sandile Dams and the Peddie Scheme. The system is made up primarily of surface water resources, with the limited groundwater resources suitable for only a few localised schemes. The latest Water Services Development Plan noted that a new raw water source needs to be identified and developed by 2010 if the basic service backlogs are to be addressed and if there is to be significant future industrial development in the city (BCM, 2007). Over time the city of East London has had a relatively large incidence of 'water loss' or non-revenue water. This occurs either through physical losses (leaks etc.), billing inaccuracies, users who are not on the database or illegal connections. The result is an increased demand on water resources, wastage of water and loss of income. According to the WSDP a comprehensive study has been undertaken and strategies to address these problems are currently being finalized.

The current poor state of sewage infrastructure and lack of proper sanitation in informal and peri-urban settlements are undoubtedly contributing to the significant pollution levels of many rivers and streams in East London, particularly the Buffalo River and dams located on the river. Coastal waters between Quinera Bay (10 km from CBD) and Leaches Bay (20 km from CBD) show 100% non-compliance with national water quality guidelines (BCM, 2005). The high incidence of pollution in these areas negatively impacts on initiatives to promote East London as a tourism destination. In addition, the city is legally obligated in terms of environmental management to ensuring the health of its citizens and protecting the environment (BCM, 2005).

East London is faced with growing challenges relating to water, sanitation and wastewater management due to increased population. As part of the process for addressing this situation, Buffalo City Municipality has embarked on a process of preparing a Sanitation Policy and Strategy (BCM, 2005). The Strategic Framework for Water Services (DWAF, 2003) sets out the national framework and targets for the water services sector for the next ten years (BCM, 2005). Figures 5.3 to 5.6 show aspects of East London and its environment.

Fig 5.3: Nahoon Dam near East London

Fig 5.4: Houses along Buffalo River

Fig 5.5: Duncan Village after a flood

Fig 5.6: Duncan Village after a fire

5.3 Port Elizabeth

5.3.1 Geographical profile

Port Elizabeth is the largest city in the Nelson Mandela Metropolitan Municipality (NMMM). The Metro comprises three main urban centres, Port Elizabeth, Uitenhage and Despatch, and covers an area of 1 951km^2. The main rivers flowing through Port Elizabeth are the Zwartkops, Baakens, Chatty and Coega rivers. These rivers have had a significant impact on spatial development within the region by, for example, affecting the transport routes in the Metro.

The city varies climatically from mild temperate conditions (8° – 23°C) along the coastal areas to slightly more extreme conditions (5° – 35°C) in inland areas, with the inland mountain areas experiencing winter snows and summer rainfalls. The average annual rainfall in Port Elizabeth is 624mm (NMMM, 2007). Port Elizabeth has five biomes; these are fynbos, grasslands, savannah, semi-desert and Afro-montane forest. In addition, there are sandy beach, rocky shore and estuarine habitats along the coast. Fig 5.7 shows a map of Port Elizabeth.

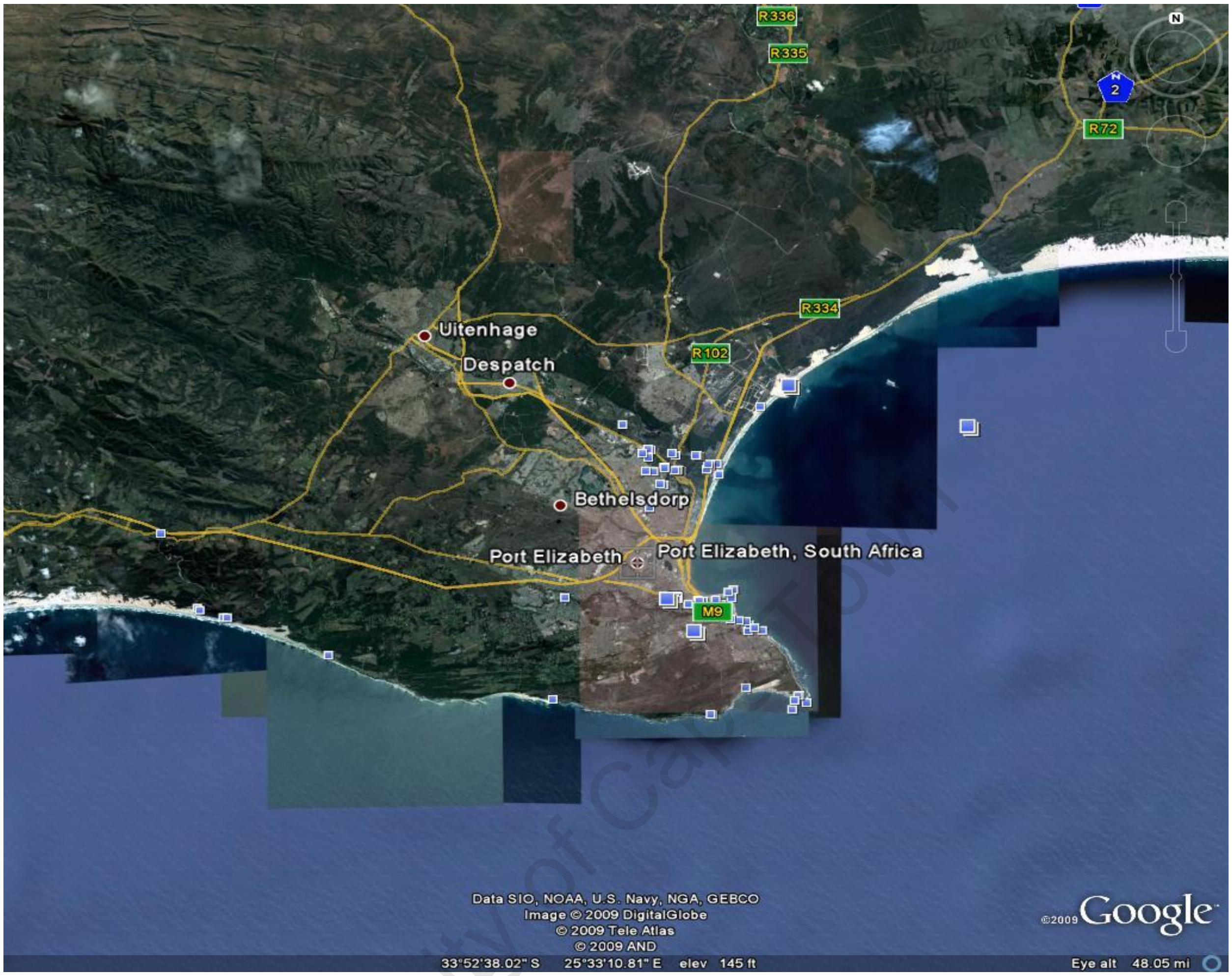

Fig 5.7: Map of Port Elizabeth (Google Earth, 2009)

5.3.2 Demographics and service provision

Port Elizabeth is considered the economic capital of the Metro and the Province, and has a population of some 1.5 million (SACN, 2006). It is an important centre for the automobile industry and a major transport hub with its well equipped airport, harbour and port. The unemployment rate among the economically active sector of the community is however still relatively high at approximately 35% (NMMM, 2008). Although this has shown a steady decline since 1994, it remains higher than the national average for South Africa. A key challenge for the city of Port Elizabeth is balancing short-term job creation with laying the platform for industries which will provide economic sustainability. The Municipality continues to provide relief to impoverished households through its ‘Assistance to the Poor Scheme’ under the Indigent Policy, and has increased its monthly free supply from 6 kl of water to 8 kl of water and free basic electricity from 50 kWh of electricity to 75 kWh per household respectively in 2007. Approximately 93 000 households receive free basic water, sanitation and refuse removal services, while almost 95 000 households receive free electricity every month (NMMM, 2008).

NMMM acts as the Water Services Authority (WSA) for Port Elizabeth. Water management in the city is subdivided into five groups whose functions are shown in Table 5.1 as per the WSDP.

Table 5.1: Water management in Port Elizabeth (NMMM, 2007)

Water Distribution	• Distribution of water to consumers. • Emergency and preventative maintenance of the water reticulation system. • Provision of water meter connections. • Technical support for development.
Bulk Water Supply	• Management of bulk water supply. • Treatment of water to potable standards and conveying it via bulk water mains to the City. • Emergency and preventative maintenance of bulk water mains, water treatment, dams and reservoirs.
Wastewater Treatment	• Management of the treatment of all wastewater. • Monitoring the discharge of commercial and industrial wastewater.
Waste Water Conveyance	• Conveyance of wastewater to wastewater treatment works. • Emergency and preventative maintenance of the sewerage reticulation system. • Provision of sewer connections. • Technical support for development
Planning and Research	• Master planning of bulk water and sanitation services to support development of the city. • Identification and design of projects to support master planning. • Identification and research of new technologies that affect water and sanitation services. • Project management and administration of identified projects.

The formal residential areas of Port Elizabeth are well serviced with respect to water and sanitation infrastructure, however, the informal settlements lack basic infrastructure. The terrain in these areas makes servicing them problematic with most of the informal settlements located on slopes or on flood plains. This poses a major challenge in service delivery to these areas. Figures 5.8 to 5.11 show various aspects of the city.

Fig 5.8 Catchment litter in Port Elizabeth

Fig 5.9 Breakages in communal taps

Fig 5.10 Typical house in formal residential area

Fig 5.11 House in an informal settlement

To conclude, the description given in this chapter provides a basic view of the current situations in both East London and Port Elizabeth. Data sheets developed during the SI application provide a more detailed appraisal of the status quo of both cities in the context of the index (see Appendices H and I).

6. Results and Discussion

In this chapter, the results obtained for the two case study cities are presented and discussed. The chapter provides an assessment of both the individual performances of each city, as well as a comparative study of the two urban centers. A comparative appraisal is also done between the results obtained from the SI as developed by De Carvalho (2007) and the revised SI (SI 2009). This chapter serves to highlight some of the factors which influenced indicator scores and discusses how the study areas can improve in water management. Unless otherwise stated the results displayed and discussed are obtained from the revised index (SI 2009). To assist in interpreting the results, a pre-determined index score range adapted from a simple traffic-light diagram is used to interpret the overall performance of the city. In validating the results, the SI performance of the cities is compared with results obtained from similar indices used on an international and national platform. An evaluation of both the SI 2007 and SI 2009 is done using an evaluation criteria matrix adapted from work done by Graymore *et al.* (2008). Furthermore, evaluation questions developed by Singh *et al.* (2008) and the United Nations (2008) in relation to indicators are used to advance the index assessment. This chapter concludes by offering a summary of the problems and limitations encountered during the research.

6.1 Comparative case study assessment

6.1.1 Comparing the results of the SI 2007 with those of the SI 2009

A comparative assessment was done of the SI 2007 and the SI 2009 for both case study cities. The performance results of East London and Port Elizabeth are shown in Table 6.1. It can be seen that there is some variation in the results of the two SI models with the social component showing the greatest variation. Overall the final SI scores obtained in the SI 2007 were higher than those of the SI 2009 in both cities. This may be that the SI 2009 contains indicators and variables which have a closer relationship to sustainability than those in the SI 2007. In addition, repetition was avoided in the SI 2009 and indicators where data was unavailable resulting in a score of 0 were taken out of the index for SI 2009. Ultimately, the SI 2009 appears to reflect a better representation of the sustainability of the urban water management in the study areas. This can be supported by the comparison of the SI 2009 results with those of international indicators, as discussed later on.

Table 6.1 Comparative assessment of study areas performance for SI 2007 and SI 2009

	SI 2007 (%)	SI 2009 (%)
	East London	
Social	76%	49%
Economic	66%	50%
Environmental	63%	45%
Political	81%	83%
Institutional	48%	52%
SI Score	**67%**	**56%**
	Port Elizabeth	
Social	72%	53%
Economic	68%	50%
Environmental	67%	50%
Political	86%	93%
Institutional	48%	52%
SI Score	**68%**	**60%**

6.1.2 Comparing the results of the two cities

Similarities between the cities of East London and Port Elizabeth help to explain the somewhat similar performance in the SI. Both cities are located in the Eastern Cape province of South Africa; this means that the same provincial authorities govern them. Similarly, geographical profile and social structure of these two coastal cities results in related environmental and social component scores. Both cities face the problem of informal settlements and housing backlogs caused by high population growth. East London and Port Elizabeth are both the main urban centres of their respective municipalities and are both tourist destinations to some extent. Table 6.2 shows the comparative SI scores for the two towns. In addition, Figures 6.1 displays graphically the similarities and differences in the cities performance.

Table 6.2: Comparative SI scores for East London and Port Elizabeth using SI 2009 results

Components	East London	Port Elizabeth
Social	49%	53%
Economic	50%	50%
Environmental	45%	50%
Political	83%	93%
Institutional	52%	52%
SI	**56%**	**60%**

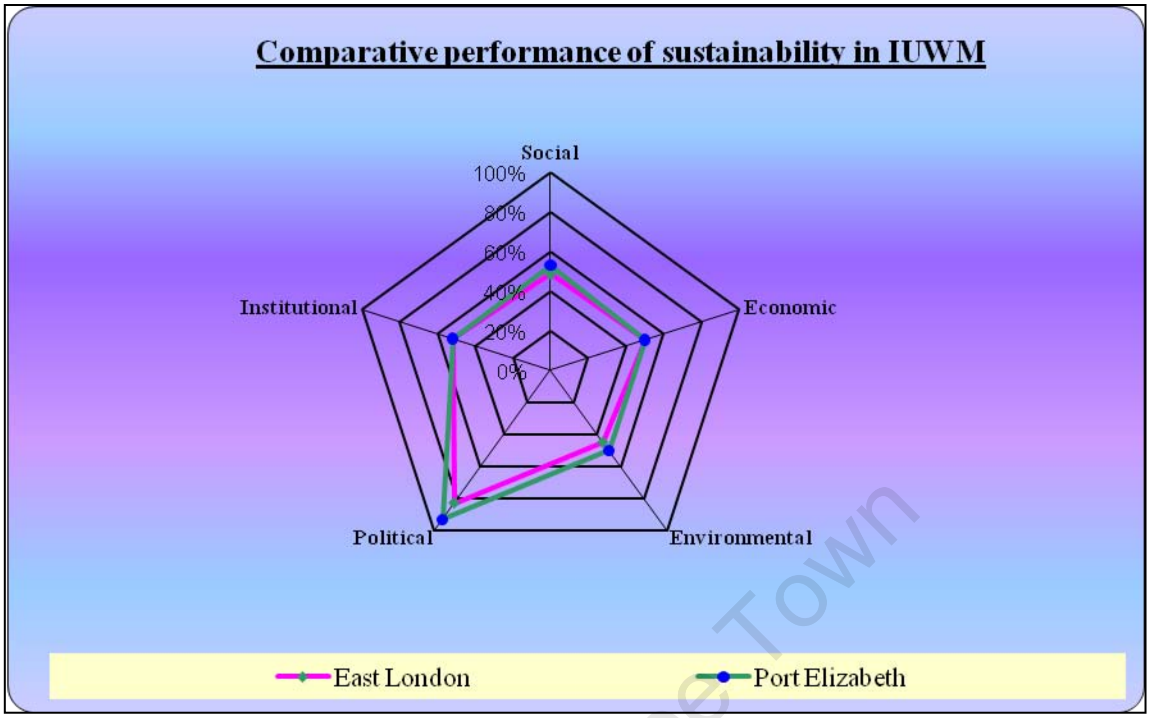

Figure 6.1 Comparative performances of East London and Port Elizabeth

The following sections give an in-depth assessment of East London and Port Elizabeth's sustainability performance using the SI 2009 results.

6.2 East London

6.2.1 Multi-dimensional sustainability performance

Considering all factors, East London displays a relatively low performance in the sustainability continuum. The city attained an overall score of 56% with the highest score being in the political component (83%) and the lowest in the environmental component (45%). There is great variation in the results of the individual components, which indicates inequalities in the spheres of water management. Table 6.3 and Figure 6.2 display summaries of the results obtained for East London in the SI (see Appendix H for full variable and indicator results). Single component analysis for East London indicates that three dimensions of sustainability show great disparity in performance with the political component being an outlier and the environmental and social components showing low performances. Social and institutional components receive low SI scores.

Table 6.3 East London's SI component scores

Components	SI Score
Social	49%
Economic	50%
Environmental	45%
Political	83%
Institutional	52%
Overall	56%

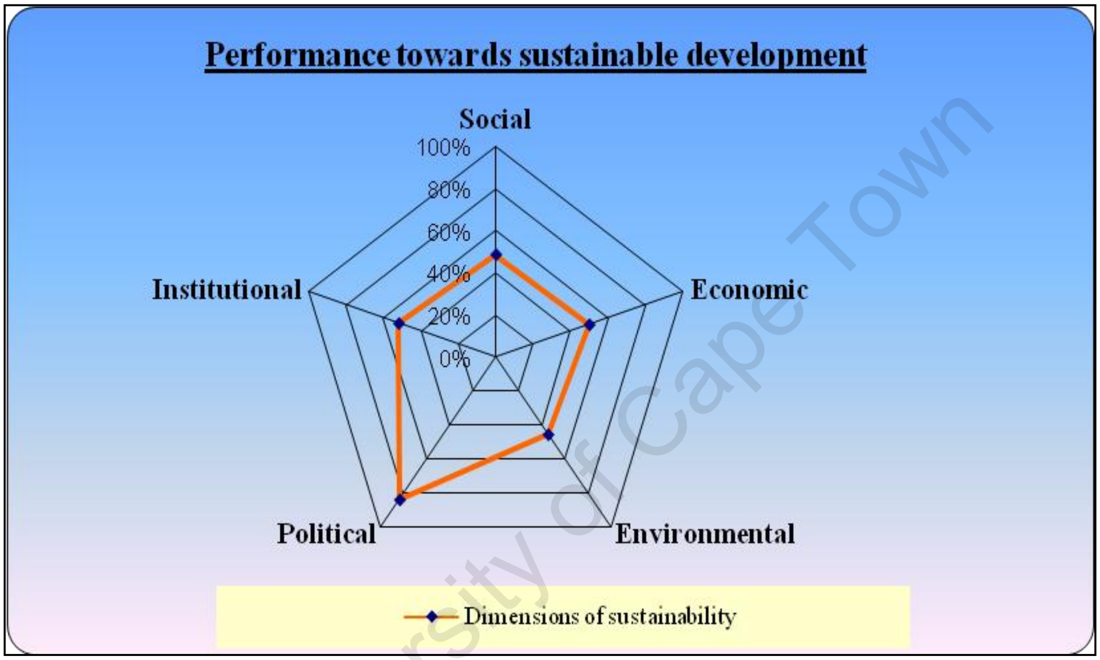

Figure 6.2 East London's SI performance

The subsequent discussion will take a closer examination at the individual components and the factors that influenced the overall index score.

6.2.2 Social dimension

East London attained a score of 49% for its SI social component which highlights the lack of strong social structures. Residents in the informal settlements of the city either have no access to basic services such as water and sanitation or have to rely on communal standpipes which are poorly maintained and often non-functional. According to the recent WSDP (BCM, 2007), 27% of East London's population do not have access to an individual house connection. However, those in formal residential areas in East London benefit from high levels of service, such as access to full water supply inside the house and waterborne sanitation.

With regard to drainage, the central parts of the town are well covered by a formal system; however some areas are prone to flooding, mostly due to the terrain of the area. The municipality is aware of the drainage problems faced in the informal settlements such as Duncan Village, but is not currently able to assist at large scale due to budgetary constraints. Waste collection in all areas of the town is undertaken regularly and efficiently. In terms of vulnerability to disasters, East London is highly susceptible to natural disasters such as flooding due to its terrain. The main disasters in East London occur in the informal settlements where fires and flooding are rampant due to illegal electricity connections and proximity to flood lines respectively. Discussions held with the municipality's Head of Disaster Management confirmed that the city is adequately prepared for the occurrence of one or more of the disasters because of the Disaster Management Plan in place and the well-trained response teams. This is also validated by information on past disaster response operations.

With regard to health, the number of deaths under 5 years per 1 000 live births (under 5 mortality rate), is relatively high and this can partly be attributed to water borne diseases to which children below 5 years old are highly vulnerable. The observed HIV/AIDS prevalence rates reduce the overall health scores even further. While HIV/AIDS prevalence is not directly related to water provision, a sufficient and accessible supply of water as well as adequate provision of sanitary services, amongst other things, can contribute significantly to building immunity and hence help mitigate the more immediate and devastating effects of HIV/AIDS. HIV/AIDS data at local level is not easily available therefore the figures used in the SI application refer to the situation in the Eastern Cape province as a whole.

Other aspects of the social component which show weak performances are the education and awareness indicators. It was noted that water management and conservation awareness only takes place during certain events such as Water Week. This is not adequate in terms of fostering a responsible and conservation based city.

6.2.3 Economic dimension

East London received a score of 50% for the economic component of the SI. This low performance is largely due to the high unemployment levels in the city and the high percentage of unaccounted for water (UFW). The UFW is caused by inadequate infrastructure maintenance resulting in leaks and damaged meters (BCM, 2007). Unmetered water and theft of infrastructure material also contributes to UFW. The city is developing strategies to reduce losses from these contributing factors. One such initiative is replacing meters with a new system that does not require municipal workers having to constantly read and record them.

With regard to the percentage of users paying for water, the block tariff approach ensures that the majority of the costs are recovered by users who use more than the Free Basic Water (FBW) whilst those unable to pay for water benefit from this FBW. Investment levels for water and sanitation infrastructure need to be increased if water management is to improve in East London. Population growth in urban areas puts pressure on resources and in order to support the increase in population considerable infrastructure upgrades and maintenance need to take place.

6.2.4 Environmental dimension

East London scored lowest in the environmental component, receiving a score of 45%. The main issue with environmental management in East London is pollution of its rivers. The majority of its rivers are non-compliant with the National Environmental Act (NEMA) regulations (BCM, 2007). The Buffalo River for example, received a River Health Index of 'poor' (RHP, 2005). The river passes through the informal settlement of Duncan Village, and the water that flows into it from this settlement increases its pollution levels greatly. The main category of users in East London is domestic and only 7% of the users fall in the industrial component (BCM, 2007). Agriculture and ecosystem maintenance are under-explored.

6.2.5 Political dimension

The political component of East London's SI performance received the highest score at 83%. The good political standing observed is largely derived from a favourable national legislative and policy water environment, which strongly advocates social justice through resource distribution, and environmental preservation, while maintaining national and international development agendas and goals. This component scores highest in all instances of indicator application and this is indicative of a solid policy and legislative background, both nationally and locally.

6.2.6 Institutional dimension

With regard to the institutional component, East London attained a score of 52%. Variables at the institutional dimension illustrate that there is an issue of under-performance at the management level, however this is not directly reflective of the capacity of current staff (education and skills) but rather highlights the under-capacity of the entire unit. East London is only at the planning stage with regard to adopting an IUWM approach. Reasons given for the delay in implementing an integrated approach are divisions in the city planning and operation structures. With regard to adopting alternative water and sanitation technologies, East London is far behind and needs to consider the options available with regard to new and possibly more sustainable technologies.

6.3 Port Elizabeth

6.3.1 Multi-dimensional sustainability performance

The overall SI score received by the city of Port Elizabeth was 60%. Although this represents a higher sustainability score compared to East London, there is still a lot of progress to be made in certain areas. The political SI component received the best result of 93%, while the environmental and economic components were relatively poor. Because there was such a varied result across the components, the final SI score is quite misleading. The subsequent sections present the breakdown and discussion of the Port Elizabeth SI results to give greater clarity and transparency. Table 6.4 and Figure 6.3 display the final SI performance assessment across the components for the city of Port Elizabeth. The full set of variable and indicator results are presented in Appendix I.

Table 6.4 Port Elizabeth's SI component scores

Components	SI Score
Social	53%
Economic	50%
Environmental	50%
Political	93%
Institutional	52%
Overall	60%

6.3.2 Social dimension

Port Elizabeth obtained a score of 53% for its social component. The 'level of service' indicator scored well with all formal areas in the city having adequate service delivery. The lowest performing indicators were those of 'education and awareness' and 'health'. Awareness regarding water management and conservation is lacking in the city and advertisements are only placed during special events such as 'Water Week'. More attention needs to be given to dissemination in order to improve its effect. With regard to health, the HIV/AIDS prevalence rate of 10% is high and this lowers the social component score. Most of the residents of Port Elizabeth experience a relatively low vulnerability to disasters. The disasters that do affect Port Elizabeth are floods and fires which occur mainly in the informal settlements. In the formal settlement areas, well-planned engineering design has reduced the risk of significant damage due to floods and fires.

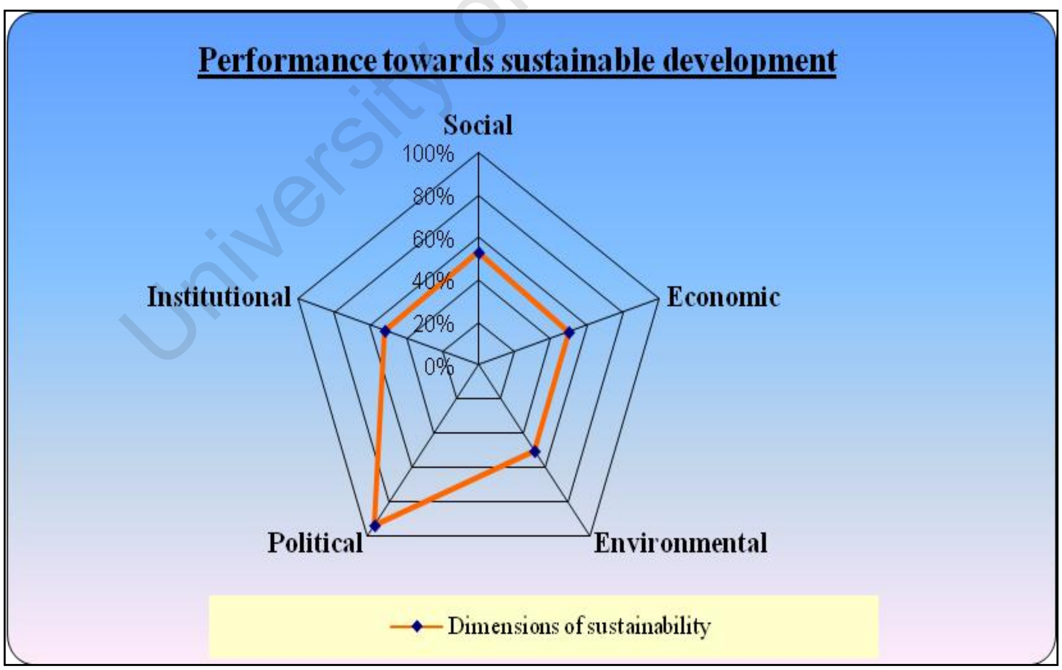

Figure 6.3 Port Elizabeth's SI performance

6.3.3 Economic dimension

As a whole, the sustainability of Port Elizabeth's economic systems with regard to IUWM needs improvement. The city scored an economic component result of 50%. The lowest performing indicator is that of 'investment levels', where the budget increase for both water supply and sanitation annually is approximately 6%. This is inadequate considering the population growth in the city as a result of migration from the rural areas. The unemployment rate in Port Elizabeth is significant at 28%. Despite this, the average household income level is quite high at R5700, indicating that the majority of households have the capacity to pay for water services. The amount of unaccounted-for-water is a major concern when it comes to cost recovery as current levels are at 35%. Most of this water is assumed to be lost due to leaks in the supply reservoirs and pipe network, as well as errors in the meter readings. The WSDP for NMMM indicated that there will be a new initiative put in place where a Global Positioning System (GPS) billing system will be used in formalized areas (NMMM, 2007). This billing system will use a satellite system to keep track of water usage in the formal residential areas thereby making readings more accurate (NMMM, 2007).

6.3.4 Environmental dimension

There are a number of concerns when it comes to the environmental dimension of Port Elizabeth's sustainability performance. The score obtained for the environmental component was 50% with the lowest performing indicators being 'wastewater management' and 'use' of resource. It was found that the quality of the rivers flowing in the urban areas of the city were below NEMA regulations and performed poorly in the RHI (DWAF, 2003). In order for the environmental component score of the city to improve, the state of the city's rivers needs to improve. This can be done by enforcing stricter penalties on industries that pollute the rivers and by creating river health awareness campaigns. With regard to 'use' of the resource, only 5% is used for maintaining the ecosystem. More of the water needs to be invested in this area in order to conserve the resource.

6.3.5 Political dimension

The result obtained for Port Elizabeth's political component is the best of the five components with a score of 93%. South Africa as a whole has a good political standing which is guided by comprehensive legislation and policies when it comes to the management of water resources and related services. There is no evidence of corruption within the local municipality as reported by those interviewed. However, it was noted that it is difficult for the municipal officials interviewed to be objective about corruption in their workplace; therefore in future, different data sources should be investigated. One such source is the Corruption Perception Index (CPI) which is a well-established index. The governance structure results in a good understanding of the various authorities' roles and responsibilities from the mayor down to the ward representatives. Port Elizabeth has a good record when it comes to progress toward achieving the MDG targets.

6.3.6 Institutional dimension

The result obtained by Port Elizabeth's institutional component is low, with a score of 52%. The poor result can be attributed to a lack of implementation of alternative water supply and sanitation technologies. In addition, the IUWM approach is only in its planning stage according to the municipality's WSDP. The monitoring capability of the city is inadequate and up-to-date information is hard to come by. An improved monitoring and data recording system needs to be put in place.

6.4 Validating the results

6.4.1 Exploring other indicators

The aim of exploring other indicators was to link the SI with existing initiatives. The results attained from this research were compared with those of similar sustainability indicators that have been applied in the study areas. The comparative indicators that were selected were largely relevant to one of the five dimensions of sustainability. For the social dimension, the Human Development Index (HDI) and Disaster Risk Index (DRI) were selected; for economic considerations the Gini coefficient and Water Poverty Index were used; and for environmental concerns, the Environmental Sustainability Index (ESI) was used. For the political component, the Corruption Perception Index (CPI) was applied. In the absence of global indicators which are indicative of institutional well-being, sub-sets of the ESI which represent institutional capacity and technological progress were used. Table 6.5 shows the results of the assessment.

This assessment indicated that there is generally good correlation between the results obtained for the two study areas and their relevant country or city scores for other indicators. However, there are significant deviations in the political dimension scores for the SI and those obtained from the CPI. This can be explained by the method in which the political component's data was gathered. This component contains qualitative data gathered from interviews with municipal authorities. The information was therefore largely subjective and somewhat biased. The CPI results shown in Table 6.5 are at a country level and are therefore not a true representation of the political performance of the study areas. However the CPI scores appear to be a more accurate measure of the political situation in the study areas than the data obtained from the interviews. For future research alternative data sources should be pursued for the political component.

Table 6.5: Comparative assessment of East London and Port Elizabeth between the SI 2009 and similar indices

SI Profile	East London SI Performance	Port Elizabeth SI Performance	Other indicators (%)		Notes
Social	49%	53%	0.53[1] (53%) 0.66[2] (66%) 40%[*]	Human Development Index (HDI) Disaster Risk Index (DRI)	HDI measures the level of development of a nation. DRI provides a measure of the national mortality risk due to exposure to certain disasters such as floods and fires
Economic	50%	50%	57.8[*] (57.8%) 52[*] (52%)	Gini coefficient Water Poverty Index (WPI)	Gini coefficient is a measure of inequality. Societies with a score of 0 have perfect equality, while those with a score of 100 have absolute inequality. WPI captures the links between water availability and livelihoods while at the same time addressing the need to maintain ecological integrity.
Environmental	45%	50%	52%[*]	Environmental Sustainability Index (ESI)	ESI benchmarks the ability of nations to protect the environment over the next several decades.
Political	83%	93%	5.1[*] (51%)	Corruption Perception Index (CPI)	CPI measures the degree to which corruption is perceived to exist among public officials and politicians
Institutional	52%	52%	40%[*]	Social and institutional capacity (ESI)	ESI Social and Institutional capacity measures that environmental governance, eco-efficiency and science and technology.
SI	**56%**	**60%**			

Notes: [1] - East London HDI (BCM, 2007); [2] - Port Elizabeth HDI (NMMM, 2007); [*] - Data for South Africa (Statistics South Africa, 2008)

6.4.2 Interpreting the results

The concept of sustainability is complex to measure or ultimately achieve, therefore an interpretive scale was developed to help in translating the results of the SI. The scale which is shown in Figure 6.5 was adapted from the traffic light diagram of sustainability (De Carvalho, 2007). The scale assists in comparing results of study areas thereby increasing the usefulness of the SI. The ranges were chosen after having studied the work of previous users of the SI (De Carvalho, Hotchkiss & Makgalemele), their final SI results and subsequent discussions on their respective study areas. The ranges shown in Figure 6.4 show the different stages of achieving sustainability in urban water management.

Categories	**Index scores**	**Measure of sustainability**
	0-40%	little/no progress towards sustainability
	41%-60%	low progress towards sustainability
	61%-80%	satisfactory progress towards sustainability
	81%-100%	highly sustainable

Figure 6.4: Interpretive results scale (Adapted from Traffic light diagram of sustainability, De Carvalho 2007)

East London attained an overall SI score of 56% and therefore falls within the 30-60% category. This means that urban water management in the city shows 'low progress towards sustainability' and changes need to be made. Port Elizabeth scored 60% overall meaning that its progress in achieving sustainable water management is slightly better than that of East London but it still falls in the same category of 'low progress towards sustainability'. An in depth discussion on the different components of urban management in Port Elizabeth has highlighted the areas which need to be improved.

6.5 Evaluating the effectiveness of the Sustainability Index

6.5.1 Evaluation criteria matrix

The following section evaluates both the SI 2007 and SI 2009 using a 'matrix point system' to assess the effectiveness of the index. Each criterion dot point (•) is given a score of 1 if it meets the criterion, 2 if it partially meets the criterion or a 3 if it does not meet the criterion at all (Graymore *et al.*, 2008). The overall criterion score is dependent on whether all of the criteria's dot points are met. If one of the dot points is partially (or not) met, then the criterion is given a score of 2 (partially met). If the average of the dot points is closer to 3, then it is given a score of 3. Only if all the dot points are met will the criterion be given a score of 1 (Graymore *et al.*, 2008). To be deemed an effective sustainability assessment indicator and a useful tool for municipality managers, the SI must achieve a score of 1 for each criteria set i.e criteria A, B and C. Table 6.6 shows the results obtained from the evaluation matrix for SI 2007 and SI 2009.

Table 6.6 Evaluation criteria matrix for SI 2007 and SI 2009

Evaluation Criteria	SI 2007	SI 2009
A. Overall effectiveness of sustainability assessment	**3**	**2**
8. Data availability and accessibility	**2**	**2**
• Uses existing data	2	2
• Data is locatable and accessible	2	2
• Data describes the region	2	2
• Data collection is cost effective (money and time)	3	1
• Ability to assess sustainability without all data	2	2
9. Assessment is easy to use	**3**	**1**
• No complicated calculations	2	1
• No specialist knowledge required (eg. matrices)	2	1
• No specialist software required	2	1
• Easy to follow method	2	1
• Easy to use	2	1
• Small indicator set (i.e. manageable data set <40 indicators)	3	1
• Not time intensive (i.e. less than 3 months to complete)	2	1
B. Method	**2**	**1**
10. Assesses sustainability directly	2	1
• Produces an overall sustainability score/index through aggregation of indicator data	1	1
• Aggregation method is logical	1	1
• Objective assessment of sustainability	2	1
• Integrated assessment including relationships between indicators	1	1
11. Information not lost during aggregation of data	1	1
• Indicator performance is reported	1	1
• Variable performance is reported	1	1
• Overall system sustainability is reported	1	1
12. Transparency in method used to produce results	2	1
• Method was clear and well documented	1	1
• Easy to understand how final results were derived from indicator data	2	1
• Simplifications and assumptions kept to minimum to reduce impact on results	2	1

Table 6.6 Evaluation criteria matrix for SI 2007 and SI 2009 (cont.)

Evaluation Criteria	SI 2007	SI 2009
C. Usefulness of results	**2**	**2**
13. Simplifies complexity of sustainability and facilitates communication to a range of audiences	1	1
• Easy to understand and interpret what results mean for regional sustainability	1	1
• Result can be described in a single page report card	1	1
• Able to visually represent the results	1	1
• Sustainability reported at a range of levels	1	1
– Detailed indicator performance		
– Sub-system/dimension performance		
– Overall system sustainability		
14. Usefulness of the sustainability assessment results	2	2
• Time and data efficiency of assessment	3	2
• For municipality officials	2	2
– Sustainability reported at a range of levels		
– Relates to policy, strategic planning, decision making		
– Points out where management actions are needed		
– Targets or thresholds to measure against		
– Can be used to assess trends overtime		
The scores are 1=meets criteria, 2=partially meets criteria and 3=does not meet criteria		

The evaluation of the index showed that the SI 2007 required some revision before it could be deemed a useful tool as it did not score 1 for any of the evaluation criteria. SI 2007 does however manage to somewhat simplify the complexity of sustainability and facilitate communication to a range of audiences as it achieves a score of 2 for this criteria. It does this by presenting overall results that are easy to understand and visually well represented. SI 2007 also reports sustainability at a range of levels by detailing indicator performance. The main weakness of the SI 2007 relates to the data collection and data input process where it scored 3 in this criterion. The user found the SI 2007 data intensive and time consuming. For this reason, the SI 2007 was revised.

The SI 2009 has been shown to be a more useful tool in assessing sustainability in an urban water management environment. The strengths of the index lie in its method where it achieved an overall score of 1. This is attributed to the transparency in the method used to produce the results and the reporting of performance at all levels of aggregation. In terms of overall effectiveness the SI attained a score of 2 mainly due to the difficulties faced in acquiring data for the index. The local municipalities have indicated that they are addressing this problem by developing monitoring and data gathering initiatives. The usefulness of the results was scored at 2. With regard to the SI 2009 simplifying the complexities of sustainability, the index succeeded by addressing the different components of sustainability. However, the usefulness of the assessment results needs to be addressed in terms of the problems of scale and applicability for municipality officials. Overall, the SI is becoming a useful advocacy tool, and with further research and testing, it will hopefully be a highly effective tool.

6.5.2 Evaluation questions

In addition to the evaluation criteria matrix, a series of questions which help to evaluate the effectiveness of the index were addressed. The answers derived from these questions give a more in-depth evaluation of the SI 2009 by asking questions that cannot necessarily be translated into a 'point' system. The questions were adapted from work done by Singh *et al.* (2008) and the United Nations (2008) in relation to indicator evaluation as follows:

h) **Flexibility**: How flexible is the index for allowing change, purpose, method and comparative application?

The SI 2009 is set for use in a South African context. The SI is flexible and can be applied at different levels, i.e. city, local municipality and provincial level although in this research only the city level was applied. The index can be used in a comparative application as done in this research with East London and Port Elizabeth.

i) **Relevance to MDGs and other global initiatives**: To what extent does the index reflect progress made towards the achievement of the MDGs?

The SI 2009 does take into account the MDG targets in its political component. Progress made toward achieving the MDG goals of water supply and adequate sanitation are accounted for in the SI 2009.

j) **Weaknesses**: What are the main weaknesses in and constraints to using the index?

The main weakness of the SI 2009 lies in the reporting of the political and institutional components of the index. In applying the index it was found that the political component results were always the highest obtained and often outliers. This was due to the indicators on democracy whose data relied on interview information from municipality officials. The measure of corruption, for example, was often reported as 'low' during interviews, yet hearsay would differ in information. One solution in dealing with this weakness would be to use different indicators for 'democracy' such as the Corruption Perception Index that is used globally. A major constraint with the index was the process of getting data from the same time series. This was due to the inconsistency in reporting at a city scale for the selected case study areas.

k) **Strengths**: What are the main positive qualities of the index?

The main strength of the SI 2009 is that it requires less time to input the data than SI 2007. This is because SI 2009 has less indicators and variables.

l) To what extent does the index reflect the **socio-economic situation** in the city?

The SI 2009 takes into account the various levels of service, health, education, vulnerability to disasters and income and in the city. These translate the socio-economic situation in the city in a clear concise manner. The results obtained for the study areas are a reflection of the socio-economic status in the cities.

m) What use is made of the **index at different levels** (community, municipality, national, regional and global)?

The SI for IUWM is still in its development stage and has only been tested at a city level thus far.

n) Is the **index able to predict** whether IUWM in a specific city is being practiced, and whether the urban water system can sustain itself?

The index does show the level of a city's adoption of an IUWM approach and highlights areas where improvement in management is needed. Cities that obtain scores in the 80-100% range are seen as being able to sustain their urban water system as per the 'interpretive results scale'.

6.6 Constraints and Limitations

To conclude, the following section summarizes some of the difficulties encountered in this research. The points raised guide the proposal of future research imperatives and improvements.

6.6.1 Problems with data collecting and accuracy of data gathered

In gathering data for this research, problems were encountered in acquiring relevant and current information. The first setback in data gathering were the restrictions placed on access to information of certain government documents such as municipal Water Services Development Plans (WSDPs). For both the cities of East London and Port Elizabeth, the researcher had to submit a PAIA Form (see Appendix F), for access to information in accordance with the Promotion of Access to Information Act (PAIA) of 2000. The form is submitted to the respective municipalities and the approval process takes 7-10 working days. In some instances, documents requested such as clinic or hospital statistics were withheld.

The second challenge faced in the data gathering process was that of getting current, regularly updated statistics at the city scale. It was found that reliable data is found only at a country scale level where organisations are employed to run surveys and census. In dealing with the study areas, the lack of data for certain indicators at a city scale led to the municipal or country level data being applied instead. This is not ideal as it leads to generalisations and misrepresentation. In modifying the index, the indicators and variables for which only country level statistics were available, were taken out in an effort to improve the accuracy of the index. In order for the index to be an effective tool there need to be improved systems for the collection and monitoring of both qualitative and quantitative data in South African cities.

Thirdly, relying on information gathered during interviews with local authorities in the water management sector can negatively contribute to the accuracy of the index result. Often government officials are not willing to speak negatively of their municipality and this then translates to untruthful information being reported and applied to the index. For example, with regard to the indicator for 'measure of corruption', most officials interviewed in the study areas citied a low level of corruption; however the Eastern Cape is reported in current newspapers as a province with the high levels of corruption. The index is strongly reliant on the accuracy and quality of the data used therefore, in future; efforts must be made to ensure good and reliable data from reputable sources to improve indicator credibility.

6.6.2 Issues of scale

In order for the SI to be successful as an advocacy tool it needs to be relatively easy and quick to apply. In terms of spatial boundaries, the problems encountered with the study areas suggested that the scale at which the index was being applied hindered its success. For instance, some of the data needed for the SI is recorded on a different scale, i.e. municipal and national as opposed to city level. The index needs to be applicable at various levels of government; therefore more case studies at different levels need to be carried out to determine the ideal component and indicator structure. In terms of the categorical scale used in the SI, its strengths lie in making variables and indicators comparable. However this scale in itself is subjective, a more refined scale of 0-10 for example, could have been chosen making it possible to identify smaller variations in indicator scores. However, the 0-10 scale was not pursued because it was initially thought that categorizing the qualitative data into ten different categories may be difficult. Where specific standards or targets were not available to assign end-points, both the end-points and intermediate ranges for each index were subject to interpretation. With regard to time scale, currently the index provides a 'snap-shot' analysis of sustainability performance. In future, it may be beneficial to use the SI to track progress in cities on an annual basis. However, there are limitations presented by the requirement of regularly updated data.

6.6.3 Conceptual framework

Assigning weights to the variables, indicators and components of the SI is a subjective task. This issue of subjectivity may only be overcome by gaining opinions from a very wide range of stakeholders. In future, stakeholder involvement in indicator selection and weighting schemes may be rewarding to the success of the SI. Indicator sets such as the ESI have opted for a less subjective equal weighting scheme which is why only the equal weighting scheme was used in this research; however, the option of choosing a weighting scheme appropriate to the index must be considered. It must be noted that for the purpose of ensuring that different case studies are comparable, it is important that the weight allocation chosen is set to a specific scheme.

In applying the SI to the study areas, the results showed that both cities perform exceptionally well in the political component. This is probably not entirely accurate and as a result this individual component can be seen as an outlier which increases the overall SI score. Further investigation showed that the political and institutional components often overlap in terms of significance. As such, the combination of the two components in future work may give a more accurate representation of sustainability in the study areas. Valentin & Spangenberg (2000) present a 'Prism of Sustainability' composed of four dimensions of sustainability, namely: social, economic, environmental and institutional, and in this case political issues of governance and policy are included in the institutional component. The option of combining the institutional and political components of the SI has both advantages and disadvantages. The institutional dimension of sustainability accounts for the fact that urban water management takes place within certain legal frameworks and is governed by policies and guidelines. It was seen that there is little difference in the subject matter of the two separate SI components, and both in fact rely heavily on the standing of the local authorities. However, the emphasis put on the political and institutional components of sustainability is reduced if the two components are combined. The political and institutional components lay the foundation upon which environmental, social and economic sustainability is achieved, and their performance is perhaps the most definitive indicator of progress towards sustainability. Sustainable development does not take place naturally and therefore relies heavily on the actions taken by the authorities. In future research, it may prove useful to attempt combining the two components and see how it affects the SI results. Additional recommendations for future work are given in the next chapter.

7. Conclusions and Recommendations

This chapter summarises the findings of the study and makes recommendations firstly for the improvement of sustainability performance in the cities of East London and Port Elizabeth, and secondly makes recommendations for future research and for the improvement of the sustainability index (SI) for integrated urban water management (IUWM).

7.1 Summary of findings

The main objective of this thesis was to improve the effectiveness of the SI as developed by De Carvalho (2007). The modification process was explained in Chapter 4 and was carried out with guidance from literature on developing good sustainability indicators as well as recommendations given by De Carvalho (2007). The SI as developed by De Carvalho (2007) and the revised SI (SI 2009) were both applied to the study areas and results were compared. East London and Port Elizabeth achieved SI scores of 56% and 60% respectively using the SI 2009 compared with 67% and 68% respectively for the SI 2007. The results indicated that East London and Port Elizabeth perform best in the political component receiving scores of 83% and 93% respectively. However, alternative data sources for the political component need to be found because those interviewed had difficulty being objective about the political situation in work-place. Both cities score lowest on the environmental component of the SI. This indicates a need for more stringent environmental monitoring. In applying the SI to the case study areas, a number of priority areas, which need to be addressed by the respective municipalities were highlighted. The following section presents recommendations for improving sustainability and IUWM in the two cities.

7.2 Recommendations for improved management of urban water systems in East London and Port Elizabeth

The following recommendations pertaining to IUWM in East London and Port Elizabeth were derived from the case study results and suggest ways in which the authorities can better address issues leading to unsustainable water management.

7.2.1 Social dimension

East London attained a score of 49% for its SI social component which highlights the lack of strong social structures. Residents in the informal settlements of East London either have no access to basic services such as water and sanitation or have to rely on communal standpipes which are poorly maintained and often non-functional. The city should therefore focus on these informal settlements. Port Elizabeth obtained a score of 53% for its social component with its lowest performing indicator being that of ‘education and awareness’. PE should therefore focus on educational campaigns regarding water use and conservation.

- Although levels of service are relatively good in the formal residential areas of the cities, there is a need for improved service delivery in the informal and peri-urban areas of both East London and Port Elizabeth. In these vulnerable areas, wider and more efficient coverage need to be addressed.
- Greater emphasis must be placed in establishing safety nets and post disaster management measures in the settlement of Duncan Village in East London. This will mitigate the impacts of natural disasters such as flooding, by addressing; inadequate supply of water, inappropriate sanitation facilities and lack of shelter.
- Continual improvement of asset management systems in the two cities is vital for efficient management of urban water systems.

7.2.2 Economic dimension

East London received a score of 50% for the economic component of the SI. This low performance is largely due to the high unemployment levels in the city and the high percentage of unaccounted for water (UFW). Port Elizabeth also scored 50% for its economic component however its lowest performing indicator was that of ‘investment levels’, where the budget increases for both water supply and sanitation annually were approximately only 6%. This is inadequate considering the population growth in the city. For both cities, the block tariff approach ensures that the majority of the costs are recovered by users who use more than the Free Basic Water (FBW) whilst those unable to pay for water benefit from this FBW.

- In East London and Port Elizabeth, knowledge regarding tariffs needs to be widely and effectively disseminated to all consumers, not only to higher income groups. This will ensure that lower income groups are aware and make use of the lower tariffs, designed for their particular needs.
- Unaccounted for water in both cities is unnecessarily high and should be addressed by way of water loss management programmes. One such initiative is replacing meters with a new system that does not require municipal workers having to constantly read and record them.

7.2.3 Environmental dimension

East London scored lowest in the environmental component, receiving a score of 45%. The main issue with environmental management in East London is pollution of its rivers. The majority of its rivers are non-compliant with the National Environmental Act (NEMA) regulations (BCM, 2007). For Port Elizabeth, there are a number of concerns when it comes to the city’s environmental sustainability performance. The score obtained for this component was 50% and great improvement must be made.

- Both case study areas scored lowest in this component, therefore the environmental aspect of water management in East London and Port Elizabeth requires the most attention in terms of improving river health and wastewater management.

- In East London, the pollution of the urban rivers such as the Buffalo River negatively affects the city's performance. Therefore, it may prove useful to improve water supply and drainage infrastructure in informal settlements where wastewater flows into the urban rivers.
- For Port Elizabeth, there needs to be a focus on the improvement of the quality of wastewater from treatment works.
- Both cities must pursue education and training initiatives to enable society to become a collaborator in the management of water rather than a contributor to the wasteful and pollutive practices that exhaust fresh water resources.
- Improved "river health" and other bio-monitoring systems should be implemented with the objective of assessing the quality and quantity of water in the natural groundwater and surface water systems. This will help authorities identify breakdowns in the urban water system.

7.2.4 Political dimension

East London and Port Elizabeth performed best in their political components with scores of 83% and 93% respectively. South Africa as a whole is guided by comprehensive legislation and policies when it comes to the management of water resources and related services. However, as discussed earlier the political scores are not a true representation of the study areas political situation.

- Both cities scored highest in the political component mainly because the South African governance structures and policy frameworks are very comprehensive in terms of highlighting the need for sustainability and equity in water management. However, the weakness lies in implementing these policies and this is largely due to inadequate technical capacity in the municipalities. This weakness however, is not being reflected in the index results therefore it may be useful to explore alternative indicators in the political component which demonstrate the true technical capacity in the municipalities.
- There is also need for wider inclusion of all groups of society in the public consultation process. In addition, stakeholder involvement in water management needs to take place at all levels of planning and not only at the end when seeking approval.
- In applying the SI to the case study areas, it was found that the political component was difficult to obtain accurate unbiased information for as municipal officials were interviewed regarding corruption in their work place. There information sometimes contradicted with that given in local papers. The Eastern Cape is often reported as having corruption problems therefore it is recommended that those in leadership positions address this issue.

7.2.5 Institutional dimension

East London and Port Elizabeth are only at the planning stages with regard to adopting an IUWM approach in their respective municipalities. In order for sustainable urban water management, these cities must move from planning to implementation.

- East London and Port Elizabeth need to recruit skilled personnel to assist in the management of service delivery. In addition, extensive on-going training of staff is recommended.
- For both cities, more attention must be given to alternative, more sustainable technologies for water and sanitation such as water saving appliances, water recycling and urine diversion sanitation systems.
- Data collection processes in the respective municipalities needs to be improved. This will ensure the accurate measurement of progress towards sustainability. It is recommended that plans be developed for acquiring data for regular monitoring.

7.3 Recommendations for future research

The research presented in this thesis has been informed by some of the recommendations for future research suggested by De Carvalho (2007). It must be noted that a number of the recommendations for future research noted by De Carvalho (2007) still stand (see Appendix C). The following are recommendations based on the revision and evaluation of the SI and the discussion points presented in Chapter 6.

- Adjust or modify the component structure of the index, and give consideration to the concept of the “Prism of sustainability” (Valentin & Spangenberg, 2000) so as to combine the institutional and political components. The combination of these two components may result in results that are a better representation of IUWM in a particular city.
- With regard to data sources for the political component, it is suggested that alternative sources be used because those interviewed were not necessarily objective about the questions asked. Independent reporting by organizations such as the United Nations on corruption and democracy in cities may be useful. The concern would be whether the data is reported at the scale needed for the SI.
- Engagement with relevant stakeholders and experts to identify pertinent issues and formulate appropriate indicators. This will help in getting expert knowledge on the issues regarding IUWM that should be addressed in the SI.
- Undertake a wider application of the index and broader testing to a variety of settings to determine the applicability and use of index. This is important because different study areas highlight various issues with regard to the effectiveness of the SI.
- Test the issue of scale by applying the index at local (neighbourhood, municipality) and national level rather than simply at city level. Applying the index at a municipality level

may prove to be advantageous, because most data in South Africa is often reported at a municipality level.

- Address the chronological dimension by tracking progress over time and maintaining good records. It is proposed that the indicator be applied on a yearly basis. This will enable recording of relevant changes, and can be aligned with specific institutional annual cycles to ensure commonality of interest and increase the potential for acceptance and use.

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Appendix A

Recommendations for future research (Extract from De Carvalho, 2007)

The following are recommendations for the improvement of the indicator, in order for it to be more relevant and reliable:

- Engagement with relevant stakeholders and experts to identify pertinent issues and formulate appropriate indicators.
- Vary indicator selection and test SI applicability to the selected two and other relevant case studies; maintaining flexibility and adaptability.
- Develop weighting schemes through the adoption of a more robust methodology for selecting weights. It is recommended that, where possible, a combination of stakeholder input and statistical analysis be employed.
- Ensure the quality of data used, and where this is not possible either eliminate the variable/index/component, or provide relevant proxies for which quality data is available.
- Undertake a wider application of the index and broader testing to a variety of settings to determine the applicability and use of index. More detailed sampling will also enable the application of statistical techniques to validate assumptions made in the development and application process.
- Apply statistical analysis methods to gauge the sensitivity and uncertainty in underlying assumptions as well as due to data gaps (imputation).
- Test the issue of scale by applying the index at local (neighbourhood, district) and national level rather then simply at city level. Explore the option of scaling up or down; firstly, as the indicator stands and secondly by readjusting the structure to suit the context. This might result in different indices for different scales.
- Address the temporal dimension by tracking progress over time and maintaining good records. It is proposed that the indicator be applied on a yearly basis. This will enable recording of relevant changes, and can be aligned with specific institutional annual cycles to ensure commonality of interest and increase potential for acceptance and use. Regarding temporal boundaries, it is also important to identify past trends, and determine how these have influenced current behaviours and events as well as what effects these can have in future practices.
- Alternative methods for calculating the index should be pursued to determine whether improved results can be obtained and/or whether less data intensive, hence resource-exhaustive approaches are possible. This also involves the investigation of whether a set of indicators is more appropriate for a particular setting rather than the composite index as used here.

Appendix B

Explanation of indicators, variables and aggregation for SI 2009

I. Social security

1. Level of Service (LOS)

The first step in moving towards some of the targets stipulated by goals such as the MDGs is to ensure that at the very least, basic levels of services are provided. The stipulation of such has been established by organisations such as WHO, who has stipulated a basic 50ℓ/c.d at distances no greater than 200m. In the same way as there are social and economic classes in society. Services have conformed to tiers of service provision, for which income levels and ability to pay are the key factors. The five levels of services are scored as shown in Table B.1.

Table B.1: Description of Level of Service

	Water supply	**Sanitation**	**Drainage**	**Waste collection**	**Rate**
LOS1	Individual house connection	Conventional sewerage Vacuum sewerage Simplified sewerage	Conventional (primary) SUDS	Frequent & reliable (weekly)	5
LOS2	Roof tanks Yard tanks & taps	Septic tanks On-plot sanitation (improved)	Conventional (primary and secondary)	Regular but infrequent (once every 2 weeks)	4
LOS3	Standpipes	On-site communal facilities	Greywater management	Infrequent (one monthly)	3-2
LOS4	Communal standpipes	Bucket toilets	No formal drainage	No formal collection (>4 weeks)	1
LOS5	None	None	None	None	0

2. Vulnerability to disasters

The notion of risk and the relationship to vulnerability and sustainability have already been introduced. The following variables will assess the susceptibility of an area and its inhabitants to one or more of the relevant natural, and at times man-induced, disasters for the study areas in question (East London and Port Elizabeth). As the risk increases, so does vulnerability. This coupled with actual exposure contribute to a lower overall sustainability, hence this is the only variable that displays an inverse relationship with sustainability of the system.

- Susceptibility to disasters: includes exposure to dolines and sinkholes; earthquakes; droughts; tornados; cyclones and floods; tsunamis or shockwaves; and fires.

Table B.2, fails to address the susceptibility to disasters occurring simultaneously in the same area (city). This is because an assumption is made that there is a low probability of more than one of the major disasters occurring at the same time within city boundaries. This, of course, is not entirely implausible and the best approach to account for such a possibility is to assign a percentage to each event.

Table B.2: Susceptibility to disasters

%	Disaster	Score (measure of exposure)
	Dolines or sinkholes	5
	Earthquakes	5
	Droughts	5
	Tornados	5
	Cyclones and floods	5
	Tsunamis or Shockwaves	4
	Fires	4
	None	0

- Risk Management and disaster mitigation

In the event of a disaster or in awareness of susceptibility to it, risk can be mitigated by good management, and appropriate design and awareness creation. In the event of poor preparedness and handling of the situation, there is an option for remediation. There are nations however which are not capacitated to engage in neither preparation and mitigation nor remediation, and are extremely vulnerable to the 'temperament' of nature.

Table B.3: Risk management

Risk management (qualitative assessment)	Score
None	5
Poor disaster management	4
Compensative risk management (remediation)	3
Effective disaster mitigation (good response)	2
Risk awareness and preparedness (prior to disaster)	1
Risk avoidance by design	0

3. Health (morbidity and mortality)

Despite the common perception that water supply can ensure improvements in health, there is no assurance that this will always be the case as there are many other factors, many of which are not related to the water sector, which can have significant detrimental health impacts. However having said this, one acknowledges that the causational link between the two as well as scientific backing as to the diseases which can and do result from poor water supply (quantity and quality) and inadequate sanitation, is sufficient to demand consideration. To address the water-health relationship, it is common to look at the most vulnerable groups who will be worst affected by poor access to water i.e. children and those with HIV/AIDS. As such the variables in this indicator are:

- Under 5 mortality rate
- HIV/AIDS prevalence

Table B.4 shows the scores for the variables.

Table B.4: Health status

Under 5 mortality rate	**HIV/AIDS prevalence**	**Score**
0%	0%	5
1%-5%	1%-5%	4
6%-10%	6%-10%	3
11%-20%	11%-20%	2
21%-30%	21%-30%	1
>30%	>30	0

4. Education and awareness

- % people with secondary education

This is the total number of people with secondary education in a given area

Table B.5 Secondary education scores

% with secondary education	**Score**
100%	5
99%-70%	4
69%-40%	3
39%-20%	2
19%-10%	1
<10%	0

- Dissemination

This variable reflects the level of education for water related matters. It includes dissemination of information and awareness creation for issues such as basic hygiene, demand water management and water wastage, resource availability and associated costs to the delivery of services (both economic and to the environment). The attribution of scores will reflect the methods for dissemination employed, the target audience and the effectiveness of approach given the socio-cultural, education and income differences amongst the wider population.

- Consultation and participation

This variable assesses the level of engagement between stakeholders in reaching decisions collectively, if not unanimously.

Scoring for the variables 'dissemination' and 'consultation and participation' are done on the basis of the following qualitative assessments: excellent (5), effective (4), satisfactory (3), poor (2), very poor (1) and nonexistent (0).

II. Economic: stability and growth

This component addresses the economic dimension of water management, exploring the necessary investments for the adequate provision of services, infrastructure development and maintenance of work. At the same time it assures the need for cost recovery. It recognises the Dublin principles which state that access to water should be made available to all, but that parallel to this; it acknowledges that water has an economic value, both as a resource and also regarding the need for collection, treatment, distribution, and discharge. In response, this indicator attempts to balance the social priorities with economic concerns.

5. Capacity

Capacity provides a measure of people's ability to access and pay for water services, based on their income security (employment) and income levels, as well as the financial demands for basic supply of services. Simply, capacity looks at people's ability to pay, given how much they must pay and how much they have, therefore indicating whether economically people have access to this essential resource.

- % unemployed

This gives the percentage of unemployed people within the study area

- Monthly income from employment (income brackets)

This variable assesses the ability of households to access and pay for water services, on the basis of monthly household incomes.

Table B.6: Capacity for accessing and paying for services

% unemployed	Monthly income brackets (R)	Score
0%	>R5000	5
1%-20%	R4999-R4000	4
21%-40%	R3999-R3000	3
41%-60%	R2999-R2000	2
61%-80%	R1999-R500	1
>80%	<R500	0

6. Cost recovery

A significant contributor to poor service provision is the lack of financial resources for expansion and maintenance. In the interest of self-sufficiency and sustainability, providers should aim for high cost recovery, provided it does not jeopardise the social precepts. In developing countries, the problem of cost recovery is one of poor payment levels combined with undesirable resource wastages.

- % users paying for water

This addresses the payment rates and return on investments aspect.

- % unaccounted for water (UFW)

There is some merit in arguing that high unaccounted for water rates in countries where illegal connections to formal supply systems is common, can to an extent constitute free basic water, however this is neither formalised nor intentionally pursued. For the purposes of the assessments carried out here it does not constitute FBW.

Table B.7: Cost recovery

% users paying for water	UFW	Score
100%	0%	5
99%-70%	1%-10%	4
69%-50%	11%-20%	3
49%-30%	21%-30%	2
29%-10%	31%-50%	1
<10%	>50%	0

7. Investment levels

Inadequate investments in water infrastructure and human capacity have proven to be the biggest constraints in efficient management of water resources and service delivery. This indicator provides a measure of the annual growth in investments in this sector.

- % of budget increase for water supply (WS)
- % of budget increase for sanitation provision (SP)
- Sources of investment

Table B.8: Investment levels

% budget increase for WS	% budget increase for SP	Investment Source	Score
>40%	>40%	Local government	5
30%-31%	30%-31%	NGOs, donor agencies	4
30%-21%	30%-21%	Regional government	3
20%-11%	20%-11%	National government	2
10%-1%	10%-1%	International aid	1
0% or decline	0% or decline	None	0

III. Environmental management and ecosystem preservation

This component proposes that the environmental dimension of sustainability be equally addressed alongside socio-economic considerations, in order to ensure that in the very least, a basic preservation of ecological systems is maintained.

8. Fresh water resources

This indicator shows the availability of water based on the existing freshwater resources for a certain area. It is assessed on the basis of per capita availability, as well as the quality of raw water supplied.

- Per capita water availability

In their Falkenmark indictor; Falkenmark, Lundqvist and Widstrand propose a basic per capita water threshold of 1700 m^3/annum. This is based on estimates of household water requirements, the needs in the agricultural, industrial, and energy sectors, and the call for ecosystem maintenance. Areas for which the per capita (yearly) water availability falls below this figure are considered water stressed. Falkenmark *et al*., also set two additional marks to identify those areas which are water scarce and extremely water scarce, for which the basic water availability targets are 1000m^3 and 500m^3 respectively. These extremes will be employed as endpoints as indicated in Table B.9.

- Water quality

This variable gives an indication of the state of fresh water resources; the degree of pollution and ultimately the cost, to us, of treating for human use.

Table B.9: Resource quantity and quality

Per capita availability (m^3)	Water quality at source	Score
≥1700	Excellent	5
1699-1500	Good	4
1499-1000	Adequate	3
999-700	Poor	2
699-500	Very poor	1
<500	Extremely polluted	0

9. Sustainability/feasibility of source

Feasibility is assessed on the basis of a number of criteria; whether water supply is local or 'imported', easily available, and whether it is abundant in its natural form and of good quality. A list of possible sources is presented and the variable is scored on the basis of what is employed and why.

Table B.10: Feasibility and sustainability of water source

%	Feasibility/sustainability of source	Score
	Local groundwater	5
	Rainwater Harvesting	5
	Local freshwater	4
	Imported groundwater	4
	Greywater	3
	Stormwater	3

Table B.10: Feasibility and sustainability of water source (cont.)

%	Feasibility/sustainability of source	Score
	Imported freshwater	2
	Brackish water	2
	Wastewater	1
	Saltwater	1

10. Use

This indicator will illustrate the water distribution per category of user, highlighting the areas which are either under or over-consuming and the need for balanced (not equal) distribution. All measurements are in percentages.

- Domestic

This is perhaps the most essential category because it addresses the basic human water requirements for drinking and hygiene maintenance. Under-consumption or over-consumption is undesirable since it can indicate that people either don’t have access to sufficient water for their basic needs or have too much, in which case are wasting. An optimal threshold was established at 100ℓ/c.d. This is double what is proposed by WHO as a minimum requirement. By doing so we propose that the limits account for more than the barest necessity and therefore consumption up to 100ℓ/c.d has a positive correlation with sustainability. Conversely, exceeding this limit implies that there is potential for wastage and inefficient use.

- Industrial

Industrial water consumption varies significantly both across different regions, being strongly dependant on the level of the development, as well as across various industries.

- Agricultural
- Maintenance of ecosystems

According to the precautionary measure, a basic share of freshwater should be reserved for the maintenance and preservation of ecosystems.

Table B.11: Water use per category of consumer

Domestic (%)	Industrial (%)	Agricultural (%)	Ecosystem Maintenance (%)	Score
60%	60%	60%	25%	5
59%-40%	59%-40%	59%-40%	24%-20%	4
39%-20%	39%-20%	39%-20%	19%-15%	3
19%-10%	19%-10%	19%-10%	14%-10%	2
9-5%	9%-5%	9%-5%	9%-5%	1
<5%	<5%	<5%	<5%	0

11. Wastewater management

This indicator monitors the discharges of wastewater, both in terms of quantity and 'river health' according to the River Health Index. It proposes to monitor the potential detrimental effects of inadequate wastewater management.

- Effluent quantity (ℓ/c.d)
- River Health Classification

Table B.12: Wastewater quantity and River Health classification

Quantity (l/person/day)	River Health Classification	Score
<20	Natural	5
20-50	Good	4
51-100	Fair	3
101-150	Poor	2
151-250	Unacceptable	1
>250	None	0

IV. Political support and stewardship

The political dimension provides an indication of the level of political support and identifies compliance with international initiatives. The measure of this is provided by two sub-indicators; governance and compliance.

12. Governance

The ideals of democracy and the precepts of sustainability are inherently connected. One can go so far as to say that democracy is the first step in ensuring that equality and sustainability issues are addressed. The three variables; democracy, corruption and definition of roles and responsibilities; can provide a basic measure of the level of support for the goals of sustainable development, towards the fulfilment of basic service provision; such as water and sanitation. In a general sense, society is almost always aware and lucid to the lack of representation and democracy, as well as to the phenomenon of corruption; however it is almost always very slow to react to it. This lack of action and response, coupled with the aspect of illegality and concealment have rendered these variables difficult to quantify; hence demanding a more qualitative assessment as seen on Table A.13.

- Democracy and representation
- Measure of corruption
- Defined roles and responsibilities

Table B.13: Assessing governance

Democracy	Scores	Defined roles and responsibilities	Scores
Full democracy	5	Supporting policy and legislation	5
Very good	4	Strong policy environment	4
Good	3	Poor implementation capacity in a good policy environment	3
Mediocre	2	Progress towards policy setting and capacity building	2
Bad	1	Inappropriate policy and poor capacity	1
None	0	Inaction (sterile environment and no progress, regression)	0

13. Progress with meeting the MDGs targets

It is important to take heed of global initiatives and international development agendas. There are many reasons for this; securing financial aid, ensuring the transfer of resources and skills, adopting well-researched and implemented practices are some of the more obvious. There are a number of such guiding international principles, such as the basic water supply and sanitation requirements stipulated by the MDGs. These are assessed in the following variables:

- % access to protected water

A measure of access to water must be inclusive of the degree to which the source is safe for human needs (drinking and washing). This variable reflects the percentage of households/communities with access to a safe water source(s).

Table B.14: Access to safe water sources

% with safe access	Access to safe source scores
>90%	5
90%-70%	4
69%-50%	3
49%-30%	2
29%-15%	1
<15%	0

- % with access to adequate sanitation

Backlogs in sanitation are even greater then those in water supply. The impact of inadequate sanitation facilities can have wide repercussive effects, on health, human development and growth, and the environment, to name the more obvious ones.

Table B.15: Access to adequate sanitation

% with safe access	Access to adequate sanitation
>90%	5
90%-70%	4

Table B.15: Access to adequate sanitation (cont.)

% with safe access	Access to adequate sanitation
69%-50%	3
49%-30%	2
29%-15%	1
<15%	0

V. Institutional capacity and technological progress

14. Institutional and technical capacity

The institutional consistency and technical aptitude of administrations is evaluated through the following variables:

- Adoption of IWRM approach

This looks at broader issue of water management, beyond the borders of the urban centre. It is complementary to IUWM and necessary to conflict free assurance of water supply for cities.

- Adoption of alternative water supply technologies
- Adoption of sustainable sanitation

Adopting alternative methods of both water supply and sanitation shows a commitment to more sustainable resource management as well as a capacity to do so. It is however unrealistic to expect a 100% conversion to alternative technologies, nor is it feasible, given the investments on more conventional approaches. This should be a gradual process which takes into account social adaptability and acceptability, economic stability and the pressure on the environment resulting from unsustainable practices.

- Monitoring capability (data collection and storage facility)
- Reliability of service provision

Table B.16: Criteria for assessing institutional and technical capacity for IUWM

Adoption of IWRM	Adoption of alternative water supply technologies	Adoption of 'sustainable' sanitation	Monitoring capability (score out of 10)	Reliability of service provision	Score
Implementation	>50%	>50%	10	100%	5
Planning	49%-40%	49%-40%	9-7	99%-80%	4
Framework development and legislative dimension	39%-20%	39%-20%	6-4	79%-50%	3
Consultation and exploration	19%-10%	19%-10%	3-2	49%-30%	2
-	9%-1%	9%-1%	1	29%-10%	1
No progress	0%	0%	0	<10%	0

Appendix C

Sustainability Index weighting sets for SI 2009

All five components of the Sustainability Index were seen to have equal value in terms of attaining sustainable urban water management. Therefore one weighting scheme was selected and this helped to simplify the SI. Table B.1 presents a detailed table that shows the 'equal and balanced' weighting scheme chosen for the SI 2009

Table C.1 Weighting sets for SI 2009

Components	Weight	Indicators	Weight	Variables	Weight
1. Social security	0.20	1. Levels of Service (LOS)	0.25	1.1 Water supply	0.25
				1.2 Sanitation	0.25
				1.3 Drainage	0.25
				1.4 Waste collection	0.25
					1.0
		2. Vulnerability to disasters	0.25	2.1 Susceptibility to natural disasters	0.5
				2.2 Risk Management and disaster mitigation	0.5
					1.0
		3. Health	0.25	3.1 Under 5 mortality rate	0.5
				3.2 HIV/AIDS prevalence	0.5
					1.0
		4. Education and awareness	0.25	4.1 % of people with secondary education	0.33
				4.2 Level of stakeholders consultation and public participation	0.33
				4.3 Level of dissemination	0.33
					1.0
2. Economic	0.20	5. Capacity (to pay or access services)	0.33	5.1 Unemployment rate	0.5
				5.2 Income levels	0.5
					1.0
		6. Cost Recovery	0.33	6.1 % users paying for water	0.5
				6.2 % of unaccounted for water (UFW)	0.5
					1.0
		7. Investment levels	0.33	7.1 % budget increase for water supply	0.33
				7.2 % budget increase for sanitation	0.33
				7.3 Sources of investment	0.33
					1.0

Table C.1 Weighting sets for SI 2009 (cont.)

Components	Weight	Indicators	Weight	Variables	Weight
3. Environmental performance	0.20	8. Fresh water Resources	0.25	8.1 Per capita water availability (l/capita/day)	0.5
				8.2 Water quality at source	0.5
					1.0
		9.Sustainability/ Feasibility of water sources	0.25	9.1 Sustainability of source	0.5
				9.2 River Health Index	0.5
		10. Use (resource distribution per sector)	0.25	10.1 Domestic	0.25
				10.2 Industrial	0.25
				10.3 Agricultural and livestock	0.25
				10.4 Maintenance of ecosystems	0.25
					1.0
		11. Wastewater management	0.25	11.1 Effluent quantity	1.0
4. Political support and international stewardship	0.20	12. Governance	0.5	12.1 Democracy and representation	0.33
				12.2 Measure of corruption	0.33
				12.3 Defined roles and responsibilities	0.33
					1.0
		13. Progress with meeting the MDGs targets	0.5	13.1 % with access to protected water	0.5
				13.2 % with access to adequate sanitation	0.5
					1.0
5. Institutional capacity and technological progress	0.20	14. Institutional capacity and technological progress	1.0	14.1 Adoption of IUWM approach	0.20
				14.2 Adoption of alternative water supply technologies	0.20
				14.3 Adoption of 'sustainable' sanitation	0.20
				14.4 Monitoring capability	0.20
				14.5 Reliability of service provision	0.20
					1.0

Appendix D

Sustainability Index instructions for using the Microsoft Excel workbook

Steps to applying the Sustainability Index (2009) using the Excel Workbook

Step	Instructions
Step 1: Data Capturing	Using the 'Fill in SI' worksheet begin to capture the city's data. Fill in this worksheet according to the following instructions: • Fill in the appropriate box, with an 'x' for each individual variable, unless otherwise instructed. Do not fill in more then one 'x' for each variable • For the Level of Service section, fill in the percentage (%) column according to the % of people served by each service • For the Susceptibility to disaster column, fill in the percentage for the type of disaster that affects the city the most • For the Sustainability of water source section, fill in the % provided by different water sources • Please ensure that for the above-mentioned sections all fill-ins add up to 100%
Step 2: Calculations	• Using the 'Calculations' worksheet, check that the data captured is accurately recorded in the Determining the rates table. • This worksheet also allows the user to see how each indicator and variable is categorised and rated. These rates determine the final scores. • The 'Calculations' worksheet, has pre-set formulas that automatically calculate the rates to be assigned from the data captured in 'Fill in SI'
Step 3: SI Results	• The 'SI weighting and results' worksheet has pre-set formulas that calculate an equal and balanced weighting system for the index components, indicators and variables rates. • The pre-set weighting and rate system determines the score for each component of the SI and the final overall SI result for the city. • The results are then displayed in a chart
Step 4: Comparing SI performance with other indicators	• This worksheet compares the individual SI component results with similar well-known indicators. • Simply input the results for the indicators for your specific city
Step 5: Comparing performance with two or more cities	• To compare the performance of two or more cities, use the 'Comparison of cities' worksheet • Final component scores are inputted in the table and a chart which illustrates the difference in performance is produced
Step 6: Interpreting the results	• Using the scale table, ascertain in which range the final SI result fits in.

Appendix E

List of Reports

E.1: List of sources and documentation for East London

Source	Document	Data
Buffalo City Municipality website: www.buffalocity.gov.za	Buffalo City Municipality Integrated Development Review 2005 - 2006	Population figures
		Income levels
		Unemployment
		Water supply LOS
		Sanitation LOS
		Solid waste LOS
		Annual budget for services
	Annual Report: Buffalo City Municipality 2006 -2007	Water supply LOS
		Sanitation LOS
		Solid waste LOS
		Education
		Income levels
		Employment
	Disaster Hazard, Vulnerability and Risk Assessment for Buffalo City Municipality	Disaster management – Vulnerability to disasters + Risk management and disaster mitigation
	Buffalo City Integrated Development Plan	Annual budget for services
www.statssa.gov.za	2007 Community survey	Water supply LOS
		Sanitation LOS
		Solid waste LOS
		Education levels
	-	2005 Census data
www.hst.org.za	-	Health data
Buffalo City Municipality Offices	Buffalo City Municipality Water Services Development Plan, 2007	Income levels
		Water operating costs
		Sanitation operating costs
		Per capita water availability
		Sources of water
	Interview with Mr. Owen Becker	Vulnerability to disaster
	Interview with Mr. Sandile Booi	Drainage LOS
		Education and awareness levels
		Sustainability strategies
		Sources of pollution
		Institutional capacity
	Information emailed from Mr. Siegfried Rousseau and Mrs. Noluvuko Mabusela	Wastewater effluent quality
		% UFW
		Sources of investment
		Non-payment
	GIS Maps of Buffalo City Municipality given by Mr. Stewart Pooley	Slope gradient
		Spatial information
	State of Environment Report : given by Mrs Shirley Ferguson	State of environment
Google Earth	-	Spatial information

E.2: List of sources and documentation for Port Elizabeth

Source	Document	Data
Nelson Mandela Bay Municipality website: www.mandelametro.gov.za	Nelson Mandela Bay Municipality Integrated Development Review 2005 - 2006	Population figures
		Income levels
		Unemployment
		Water supply LOS
		Sanitation LOS
		Solid waste LOS
		Annual budget for services
	Annual Report: Nelson Mandela Bay Municipality 2006 -2007	Water supply LOS
		Sanitation LOS
		Solid waste LOS
		Education
		Income levels
		Employment
	Disaster Hazard, Vulnerability and Risk Assessment for Nelson Mandela Bay Municipality	Vulnerability to disaster
	Financial Report 2006	Annual budget for services
www.statssa.gov.za	2007 Community survey	Water supply LOS
		Sanitation LOS
		Solid waste LOS
		Education
	-	2001 Census data
www.hst.org.za	-	Health data
Nelson Mandela Bay Municipality offices	Nelson Mandela Bay Municipality Water Services Development Plan, 2007	Income levels
		Water operating costs
		Sanitation operating costs
		Per capita water availability
		Sources of water
	Interview with Mr. Henry Lansdown	Vulnerability to disasters
	Interview with Mr. Barry Martin	Drainage LOS
		Education and awareness levels
		Sustainability strategies
		Sources of pollution
		Institutional capacity
	Information emailed from Mr. Anderson Macotywa	Wastewater effluent quality
		% UFW
Google Earth	-	Spatial information

Appendix F

PAIA Form for access to information

FORM A

REQUEST FOR ACCESS TO RECORD OF PUBLIC BODY
(Section 18(1) of the Promotion of Access to Information Act, 2000

(Act No. 2 of 2000)

[Regulation 6]

FOR DEPARTMENTAL USE

Reference number:

Request received by
name and surname of information officer/deputy information officer on
(date) at (place)
Request fee (if any): R………………………
Deposit (if any): R ………………………
Access fee: R………………………

…………………………………………….Signature of information officer/deputy
Information Officer

A Particulars of public body
The Information Officer/Deputy Information Officer:

B Particulars of person requesting access to the record

(a) The particulars of the person who requests access to the record must be given below.

(b) The address and/or fax number in the Republic to which the information is to be sent, must be given.
(c) Proof of the capacity in which the request is made, if applicable, must be attached.

Full names and surname:
Identity number:
Postal address:
Fax number:
Telephone number:
E-mail address:
Capacity in which request is made, when made on behalf of another person:

C. Particulars of person on whose behalf request is made

This section must be completed ONLY if a request for information is made on behalf of another person.

Full names and surname:
Identity number:

D. Particulars of record

(a) *Provide full particulars of the record to which access is requested, including the reference number if that is known to you, to enable the record to be located.* *(b) If the provided space is inadequate, please continue on a separate folio and attach it to this form.* The requester must sign all the *additional* folios.

1 Description of record or relevant part of the record:
2 Reference number, if available:
3 Any further particulars of record:

E. Fees

(a) *A request for access to a record, other than a record containing personal information about yourself, will be processed only after a* request fee *has been paid.* *(b) You will be notified of the amount required to be paid as the request fee.* *(c) The* fee payable for access *to a record depends on the form in which access is required and the reasonable time required to search for and prepare a record.* *(d) If you qualify for exemption of the payment of any fee, please state the reason for exemption.*

Reason for exemption from payment of *fees:*

F. Form of access to record

If you are prevented by a disability to read, view or listen to the record in the form of access provided for in 1 to 4 below, state your disability and indicate in which form the record is required.

Disability:	Form in which record is required:

<table>
<tr><td colspan="6">Mark the appropriate box with an X.
NOTES:
(a) Compliance with your request for access in the specified form may depend on the form in
which the record is available.
(b) Access in the form requested may be refused in certain circumstances. In such a case
you will be informed if access will be granted in another form.
(c) The fee payable for access to the record, if any, will be determined partly by the form in
which access is requested.</td></tr>
<tr><td colspan="6">1. If the record is in written or printed form:</td></tr>
<tr><td></td><td>copy of record*</td><td></td><td colspan="3">inspection of record</td></tr>
<tr><td colspan="6">2. If record consists of visual images -
(this includes photographs, slides, video recordings, computer-generated images, sketches, etc:</td></tr>
<tr><td></td><td>view the images</td><td></td><td>copy of the images*</td><td></td><td>transcription of the images*</td></tr>
<tr><td colspan="6">3. If record consists of recorded words or information which can be reproduced in sound:</td></tr>
<tr><td></td><td>listen to the soundtrack
(audio cassette)</td><td></td><td colspan="3">transcription of soundtrack*
(written or printed document)</td></tr>
<tr><td colspan="6">4. If record is held on computer or in an electronic or machine-readable form:</td></tr>
<tr><td></td><td>printed copy of record'</td><td></td><td>printed copy of information derived from the record*</td><td></td><td>copy in computer readable form*
(stiffy or compact disc)</td></tr>
<tr><td colspan="4">*If you requested a copy or transcription of a record (above), do you wish the
copy or transcription to be posted to you?
Postage is payable.</td><td>YES</td><td>NO</td></tr>
<tr><td colspan="6">Note that if the record is not available in the language you prefer, access may be granted in the
language in which the record is available.</td></tr>
<tr><td colspan="6">In which language would you prefer the record?</td></tr>
</table>

G. Notice of decision regarding request for access

You will be notified whether your request has been approved/denied. If you wish to be informed in another manner, please specify the manner and provide the necessary particulars to enable compliance with your request.

How would you prefer to be informed of the decision regarding your request for access to the record?
Signed at …………………………….. this ………..day of……………………………20

SIGNATURE OF REQUESTER 1 PERSON ON
WHOSE BEHALF REQUEST IS MADE

Appendix G

List of individuals contacted and interviewed

Name	Organisation	Telephone number.	Fax number	Cell phone number	Email address	Physical address
Buffalo City Municipality (East London)						
Siegfried Rousseau	Senior Water Resource Manager Amatola Water	043 707 3700	043 707 3701	083 320 5262	srousseau@amatolawater.co.za	Amatola House, 6 Lancester Road, Vincent 5247, East London
Sandile Booi	Manager Water Services Authority: BCM	043 705 2246	043 743 5266	082 371 2451	sandileb@buffalocity.gov.za	
Owen Becker	Director of Disaster Management Centre	043 743 7118			owenb@buffalocity.gov.za	DMC, Fire Management Centre,Fleet Street, EL
Werner Bernadie	Area Plant Superintendent at Nahoon Dam					
Pamela & Linda	Staff in the Archives Department in EL					Trust Centre Cnr North and Oxford, 5th floor.
Noluvuko Mabusela	Manager for Scientific Services at Nahoon Dam					
Shirley Ferguson and Jane	Environmental department	043 707 5800		083 561 0698	shirleyf@buffalocity.gov.za	
Annamarine Botha	Head of GIS for BCM	043 705 3121				Municipal Building, GIS Unit, Rrm 328
Stewart Pooley	GIS staff	043 705 2348			stewartp@buffalocity.gov.za	Engineers Building
Connie Buso	Amatola Water staff	043 707 3700	043 707 3701		cbuso@amatolawater.co.za	
Graham Carley	Water Manager for BCM	043 705 2275				

Name	Organisation	Telephone number	Fax number	Cell phone number	Email address	Physical address
Nelson Mandela Bay Municipality (Port Elizabeth)						
Henry Lansdown	Assistant Director Disaster Management NMBM	041 501 7900	041 585 2394	079 490 0626	hlansdown@mandelametro.gov.za	PO Box 579, Port Elizabeth 6000
Shane Brown	Director Disaster Management NMBM	041 501 7900	042 585 2394		sbrown@mandelametro.gov.za	PO Box 579, Port Elizabeth 6001
Barry Martin	Director of Water and Sanitation	041 506 5435	041 506 5647		bmartin@mandelametro.gov.za	
Anderson Macotywa	Ass Director of wastewater	041 506 2172			amacoty@mandelametro.gov.za	Brister House, Govan Mbeki Avenue, 1st Floor in Scientific Lab Service Unit
Peter Reties	DWAF PE	041 586 4884				
Monde Ganyaza	Info officer; Legal services	041 505 4580	041 505 4435		mganyaza@mandelametro.gov.za	Brister House, Govan Mbeki Avenue
Abigail Kamineth	Conservation Planning/EM	041 506 5464			akamineth@mandelametro.gov.za	

Appendix H

East London SI data verification and full results

H.1: East London data verification

I. Social security

1. Access to water supply

1.1 Total collection time: Dependant on LOS

1.2 Gender Bias:

The gender profile of the Buffalo City Municipality (BCM) population, based on Census 2001 data was used and is shown in Table H.1.

Table H.1: Population Gender Profile

2001		1996	
Female	Male	Female	Male
372 730	329 159	362 650	324 297
53.10%	46.90%	52.79%	47.21%

Source BCM WSDP pp 1.10

From the above table it can be seen that, for the time period under consideration, the female population grew at a faster rate than the male population.
Gender bias is therefore 46.9/100*53.10= 24.90 Input: 25%

1.3 Conflict over water sources

It was assumed that conflict over water is very minimal since majority of the people are serviced with at least a standpipe within 200m of their dwelling. Conflict only occurs when service delivery is interrupted and that does not occur often. Input 1-10%.

1.4 % with access to protected water

The municipality have fulfilled their minimum legal requirement of providing everyone within their jurisdiction with safe water. Poor maintenance of these systems at various times has resulted in poorer access however this is generally temporary and thus insignificant. Input= >90%

2. Access and use of sanitation facilities

2.1 Number of people per sanitation facility: Dependant on LOS

2.2 Safety of use and to access facilities: Dependant on LOS

2.3 Cultural and social acceptability: Dependant on LOS

There is generally a high level of service and high percentage of waterborne toilet facilities (64%) which reflects both good accessibility and acceptability of sanitation services. However, with the remaining 36% that either has on-site communal toilets or bucket toilets, the level of acceptability is very low as the communal toilets are badly maintained resulting in odour issues and visual and physical contact with excreta. This is neither culturally nor socially accepted.

3. Levels of service

3.1 Water supply

Based on the dwelling count data and the geo-database prepared as part of the Water Services Master Plan, the profile of the residential consumer (in terms of water) is as presented in Table H.2. It must however be noted that for the purposes this table “Urban” has been defined as those settlements within the Urban Edge and “Rural” as those outside of the Urban Edge, as defined by the SDF of 2003.

Table H.2: Level of service in water supply

No. Consumer units with:	Urban	Rural	Farm	Other
1 .None or adequate	44538	4165	Unknown	Included with farms
2. Communal water supply	16811	57758	Unknown	Included with farms
3. Controlled volume supply	0	0	Unknown	Included with farms
4. Uncontrolled volume supply: yard tap or house connection	102703	0	Unknown	Included with farms
5. Total served (2+3+4)	119514	57758	Unknown	Included with farms
6. Total	164052	61923	4352	Included with farms

From the above information the following input results were determined:

Table H.3: LOS of water supply input values

Level of Service	% of total HH
1	63
2	0
3	0
4	10
5	27

3.2 Sanitation

It was stated in the Census 2001 report that the state of sewage and sanitation services in East London is probably the most serious environmental issue facing the city.

Table H.4: Sanitation LOS according to the Census 2001

Households	2001	%	1996	%
Flush Toilet	122,101	64%	107,644	67%
Flush septic tank	4,723	2%	-	0%

Table H.4: Sanitation LOS according to the Census 2001 (cont.)

Households	2001	%	1996	%
Chemical toilet	2,180	2%	-	0%
VIP	6,668	3%	-	0%
Pit latrine	29,027	15%	33,515	21%
Bucket latrine	2,723	2%	2,106	1%
None	23,624	12%	16,209	10%
TOTAL	191,046	100%	159,474	100%

Source: Census 2001

Table H.5: LOS of sanitation facilities input values from Census 2001

Level of Service	% of total HH
1	64
2	2
3	20
4	2
5	12

3.3 Drainage

Information gathered from the WSDP estimated that 80% of EL is serviced with hardened tarred roads with full conventional drainage systems. There are however no grey water management procedures in place at present for the informal urban settlements and the dense peri-urban type areas such as Duncan Village. These settlements are either serviced with on-site dry sanitation systems (peri-urban) or communal waterborne sanitation systems (informal), that are poorly maintained. Due to the levels of service currently being provided, it is not anticipated that the need for grey water management will become significant for formalized dense urban settlements. This would however change should acceptable alternative on-site sanitation solutions be found and delivered at scale. There is however a need to address greywater management in existing dense peri-urban settlements and in the informal settlements. EL has not implemented any form of SUDS. One area that is totally un-serviced with respect to drainage systems is the informal settlement Duncan Village. Due to the topography (flood-prone, hilly area), it is difficult to put service delivery infrastructure.

Table H.6: Drainage LOS according to the WSDP

	Drainage	Rate	Percentage
LOS1	Conventional (primary and SUDS) Formal	5	80
LOS2	Conventional (primary)Basic formal	4	0
LOS3	Grey-water management (Basic informal)	3	0
LOS4	No formal drainage	1	10
LOS5	None	0	10

3.4 Waste collection

According to Census 2001 data, about 70% of the people in BCM have their waste removed once a week by the local authority. The next most common way of getting rid of rubbish is by burning it in a pit (own dump), with nearly a quarter of the households doing so. Illegal dumping and littering is widespread throughout BCM. While this can probably be attributed in part to the lack of waste services and locations (stations) for depositing waste, lack of awareness and enforcement of illegal dumping regulations also contribute to the problem. The accumulation of waste due to lack of services and littering especially in the previously disadvantaged areas is a serious problem and has effects on infrastructure i.e. the blockage of storm-water drains and sewers, resulting in effluent flow on the surface. Blocked sewers can lead to pollution and health risks.

Table H.7: Waste collection LOS

Households	2001	%	1996	%
Municipal Weekly	136,316	71%	93,822	59%
Municipal Other	2,242	1%	10,057	6%
Communal Dump	1,599	1%	5,264	3%
Own Dump	41,412	22%	39,003	25%
No Disposal	9,477	5%	9,753	6%
Total	191,046	100%	157,899	100%

4. Vulnerability

Information gathered for this section was gathered from an interview with Mr. Owen Becker (Head of Disaster Management in BCM) and the BCM Disaster Management Plan.

4.1 Susceptibility to disasters

- Dolines & sinkholes: Assumed zero since there is no dolomite in the area.
- Earthquakes: Earth tremors could affect the whole area. There is an epicentre in the east coast therefore as a result of the geology, an earthquake is possible.
- Droughts: There are 3-12 year cycles during the drought cycle which happens every 3-12 years there is a drought. This affects entire BCM area.
- Tornados: Occur 5-6 times annually. Severe storms including strong winds, hail, lightning and heavy rain occur mainly in the inland areas South and East of the Amathole Mountains.
- Cyclones & Floods: No cyclones; however there is a probability of a cyclone since East London is a coastal town. Flooding does occur during the wet periods, and this affects the entire BCM.
- Tsunamis or shockwaves: coastal problem

- Fires: Fires do occur in the following: veld and forest (whole area), informal (informal sector) industrial and commercial (whole area) institutional (schools and hospitals). The main causes of fires in the informal settlement are flame, candle, electrical fault and arson.

Table H.8: Vulnerability to disasters data input

%	Susceptibility to disasters
0	Dolines or sinkholes
2	Earthquakes
4	Droughts
10	Tornados
30	Cyclones & floods
2	Tsunamis or shockwaves
30	Fires
22	None
100	Total

4.2 Risk management and disaster mitigation

The hub of Disaster Management is the Disaster Management Centre, and the capacity of the centre determines the potential to manage disaster. The current capacity in terms of staff, information and institutional framework and funding is severely lacking. This will need to be corrected if Buffalo City is to carry out the Disaster Management functions of a Metropolitan Municipality. The current staff for BCM is a Disaster Management Officer, a Disaster Management Trainee and a clerical post. A minimum of eight staff is required to provide an acceptable level of service. This will need to further increase to approximately 20 which is the minimum staffing level for Disaster Management in Metropolitan Municipalities. The over priority issue is the lack of an integrated approach to disaster management in BCM, which results in unsustainable development with unacceptable human, economic and environmental losses. Input: Risk awareness and preparedness

5. Health status

There appears to be little readily available data regarding water related diseases within EL. Statistics were however obtained from Department of Health for diarrhoea incidences (per 1000 population) recorded at the various clinics within BCM. Areas of high incidences are closely aligned with the informal and low income settlement areas within East London, which invariably have access to inadequate sanitation services e.g. Duncan Village. For the health statistics, data from the Eastern Cape will be used, because there is no readily available data for East London.

5.1 Under 5 mortality rate

Definition: the number of children under 5 years who die in a year, per 1 000 live births during the year. It is a combination of the infant mortality rate, plus the age 1-4 mortality rate.

Table H.9: Under 5 mortality rate for each province (Deaths under 5 years per 1 000 live births) (HST, 2008)

	EC	FS	GP	KZN	LP	MP	NC	NW	WC	South Africa
2003 SADHS	79.1	68.2	42.6	33.2	43.9	52.2	39.1	76.3	56.5	57.6
2008 ASSA2003	87.4	82.8	55.8	90.3	53.6	75.9	49.6	65.6	38.1	68.9

Input: 9%

5.2 Malaria-related mortality rate

East London is not in a malaria affected region; the malaria-related mortality rate is thus assumed to be zero. Input: 0%

5.3 Reported cases of intestinal and infectious diseases per 1000

Table H.10: Reported cases of cholera (per 1000) (HST, 2008)

Year	South Africa (ZA)
2000	0.24
2001	2.21
2002	0.36
2003	0.08
2004	0.06
2005	0.00

Table H.11: Reported cases of typhoid (per 1000) (HST, 2008)

	EC	FS	GP	KZN	LP	MP	NC	NW	WC	South Africa (ZA)
1998	0.026	0.000	0.001	0.004	0.017	0.005	0.003	0.000	0.002	0.003

From the above information it was concluded that infectious water borne diseases are insignificant. This can be attributed to the fact that access to safe drinking water is quite good in South Africa, especially in the urban areas. Input: 0%.

5.4 HIV/AIDS prevalence

Table H.12: HIV prevalence (% of population) (HST, 2008)

	EC	FS	GP	KZN	LP	MP	NC	NW	WC	ZA
2006 ASSA2003	10	13.9	14.5	15.7	6.9	13.4	6.9	12.7	5.4	**11.2**
2007 ASSA2003	10.4	14	14.7	15.8	7.1	13.4	7.2	12.9	5.6	**11.4**
2008 ASSA2003	10.8	14.1	14.7	15.8	7.3	13.5	7.5	13	5.8	**11.6**

Input: 10%

6. Education and awareness

6.1 Level of dissemination

The BCM WSDP indicates that there is no budget or personnel set aside for public education and awareness programmes relating to water. It is however something which has been prioritised and will be addressed in the near future. At present the East London gets involved in initiatives organised by DWAF such as *water week* and *sanitation week*. Input: Satisfactory.

6.2 Level of stakeholder consultation and public participation

The BCM's public documents such as the IDP and WSDP indicate quite a high level of stakeholder consultation and public participation. According to Mr. Sandile Booi the manager for BCM Water Services Authority; there is usually direct communication with affected parties before any construction takes place. Formal communication takes place through the ward representative. Input; Effective.

II. Economic: stability and growth

7. Capacity

7.1 % of people with secondary education:

The highest education levels of persons over 20 years of the age in East London are as presented in Table H.13. Input: 66.64%.

Table H.13: Education Profile of Persons 20 years and older (BCM, 2007)

Education levels	1996	2001	% change
No schooling	12.74%	10.98%	-3.96%
Some primary	14.92%	14.60%	9.05%
Complete primary	9.44%	7.78%	8.23%
Secondary	39.39%	35.92%	1.60%
Grade 12	16.72%	21.20%	41.31%
Higher	6.79%	9.52%	56.31%

7.2 Unemployment rate

Information based on the findings of the SACN report showed that the BCM economy has seen a decline (in absolute and/or relative terms) in the primary and secondary sectors of the economy, but growth in the tertiary sector. This transition has had an impact on the employment profile of BCM. Furthermore, like many cities, there has been a trend of declining formal employment and increasing informal employment. According to the SACN report, 23% of the employed population in BCM works in the informal sector and 77% in the formal sector. The employment levels within BCM are as presented in Table H.14.

Table H.14: Employment Profile of the BCM Workforce

Potential Labour Force	1996	2001	% Change
Employed	34.49%	29.19%	-13.15%
Unemployed	21.82%	33.06%	55.48%
Not economically active	43.70%	37.74%	-11.38%
Total labour force	464397	476457	2.60%

Input: 33.06%

From the above table the following can be noted regarding the potential labour force:

- Its growth rate has exceeded the population growth rate;
- The % unemployed has increased since 1996 and was at 33% as at 2001; and
- The % not economically active has decreased.

Note: "An unemployed person according to the official definition is a person between the ages of 15 and 65 with responses as follows: 'No, did not have work'; 'Could not find work'; 'Have taken active steps to find employment'; 'Could start within one week, if offered work'." (www.statssa.gov.za).

7.3 Income levels:

The monthly household income distribution within East London is as presented in Table H.15.

Table H.15: Profile of Monthly Household Incomes

Monthly Income	% of Households		
0	28.67	0.2867	0
400	6.67	0.0667	26.68
800	18.91	0.1891	151.28
1600	15.12	0.1512	241.92
3200	11.52	0.1152	368.64
6400	8.13	0.0813	520.32
12800	6.21	0.0621	794.88
25600	3.34	0.0334	855.04
51200	0.83	0.0083	424.96
102400	0.23	0.0023	235.52
204800	0.3	0.003	614.4
204800	0.09	0.0009	184.32
		Weighted Mean	4417.96

Input: 4417.96 >R3500

7.4 No. of days taken off work due to water-related diseases

From the health statistics it can be assumed that a minimum number of days are lost due to water-related diseases. Input 1-10 days.

7.5 Minimum/Basic water tariff
Information from the WSDP stated that the basic water tariff is R0-R0.9. Input: R0-R0.9

8. Cost recovery

8.1 % of users paying for water

Table H.16: Profile of Urban Domestic Consumers within BCM

Consumer category	Greater East London	King Williams Town	Mdantsane	Total	% of Total
Metered	30 106	16 389	12 824	59 319	57.8
Flat Rated	4209	8 033	579	12 821	12.5
Indigent	8188	6 588	15 765	30 541	29.7
Total	42 503	31 010	29 168	102 681	100

% Users = 30 106+4209/42503*100= 80.8% Input: 99-70%

8.2 % of Unaccounted for Water (UFW)

Mr. Sandile Booi stated that the % of UFW is between 35-40%, but there are strategies in place to avoid such losses, for example actual meter readings (as opposed to flat rate meters/readings) and education and awareness through pamphlets. Mr. Barry Martin – noted that the UAW is what produced verse what is billed is. There is a new initiative where BCM hopes to put 200 standpipes, GPS and a billing system. Input: 31-60%

8.3 % of Free Basic Water

This is calculated from 6000kl/households of 4 which is the South African water standard. Input: 50ℓc.d.

9. Investment levels

9.1 % budget increase for water supply

Information gathered from the WSDP stated that the operating costs for water are anticipated to increase fairly significantly moving forward, despite budgeting currently only reflecting increases in the order of 5% p.a. The increased budgetary requirement is largely attributed to:

- Increased capital works to support private and public sector development
- Increased purchases of raw and potable water supplies
- Increased salary costs

- Increased costs and extent of maintenance (shows decreasing trend in current budgeting)

Input 5%

9.2 % budget increase for sanitation

Operating costs for sanitation are anticipated to increase fairly significantly moving forward, despite budgeting currently only reflecting increases in the order of 5% p.a. The increased budgetary requirements are largely attributed to:

- Increased capital works to support private and public sector development;
- Increased salary costs; and
- Increased costs and extent of maintenance (shows decreasing trend in current budgeting)

Input 5%

9.3 % budget increase for Operating &Maintenance

Water: Operating budgets have been inadequate to effectively operate and maintain existing infrastructure. Salary and finance charges indicate a constant trend, at 15% and 9% of the budget respectively, despite the extent of infrastructure provided increasing.
Maintenance budgets indicate a declining trend, and are considered to be 67% of what is required excluding provision for depreciation, and 10% of what is required including provision for depreciation.
Provision for maintenance is currently less than 10% of the revenue budget, resulting in ad hoc reactive maintenance.

Sanitation: Operating budgets have been inadequate to effectively operate and maintain existing infrastructure.
Salary and finance charges indicate a constant trend, at 52% and 9% of the budget respectively, despite the extent of infrastructure provided increasing. Maintenance budgets indicate a declining trend, and are considered to be 25% of what is required excluding provision for depreciation and 11% what is required including provision for depreciation. Provision for maintenance is currently less than 10% of the revenue budget, resulting in ad hoc reactive maintenance. Input: 9-5%

9.4 Sources of investment

According to the WSDP and interview with Mr. Sandile Booi the National Government is the main source of investment for BCM but for EL it's the local municipality. Input: Local government.

III. Environmental performance

10. Fresh water resources

10.1 Per capita water availability (m^3) per annum

East London falls entirely within the Amatole Catchment comprising about 25 smaller quaternary catchment areas. The Amatole Catchment covers an area of 7936 km2. The area receives a mean annual precipitation of 675 mm per annum and has an annual evaporation of 1406 mm per annum.

The region has naturalised mean annual runoff of 580 x 106 m3 per annum and a maximum potential yield of 442 x 106 m3/a (DWAF, 1999). About half of the maximum potential yield is utilised within the entire drainage area. The mean annual groundwater harvest potential is approximately 136.28 x 106 m3 per annum (DWAF, 1999). Major catchment rivers in East London include the Keiskamma, Tshlomonga , Buffalo, Nahoon, Gqunube and Kwelera Rivers.

Table H.17: Water availability in Buffalo City Municipality

Dam	**Available Yield 10^6 m^3/yr**	**Projected Water Requirement (2005) 10^6 m^3/yr**	**Surplus (2005) 10^6 m^3/yr**	**Projected Water Requirement (2010) 10^6 m^3/yr**	**Surplus/ (Shortfall) (2010) 10^6 m^3/yr**
Rooikrans & Maiden	3.1	5.6	(2.46)	6.1	(3.0)
Laing	14.8	7.9	6.9	9.9	4.9
Nahoon	5.6	5.1	0.5	6.4	(0.8)
Bridle Drift	28.7	48.5	(19.8)	58.6	(29.9)
Wriggleswade	16.9	0.1	16.8	0.1	16.9
TOTAL	69.1	67.2	1.9	81.1	(12.0)

Source: SoE report pg 40

Total is 69 1000 000/ population of BCM 701 895 = 984.477. Input: 999-700m^3

10.2 Reliability (in terms of variability, seasonality) at source

The climate of East London varies from mild temperate conditions (8 to 39 ^{0}C) along the coastal areas with a mean annual value of 18 °C. Rainfall in East London varies from 400 to more than 1000 mm per annum, with an annual mean value of about 700 mm. The highest precipitation occurs in the Amatole Mountains (BCM) and in the coastal region. Most of the rainfall occurs during summer, except in the coastal area west of East London, where rainfall occurs year-round. The area is sometimes affected by droughts. Inputs: 99-80%.

10.3 Water quality at source

The recent most WSDP indicates that the quality of surface water in the main East London catchments is deteriorating due to salinization and industrial and domestic effluent contamination, with this being particularly prevalent along the Buffalo and Nahoon River catchments. Apart from the environmental impacts, this can result in higher treatment costs related to eutrophication. Poor water quality conditions of water resources in BCM are the result of various contributing factors, such as:

- Poor sanitation in rural, informal and low income settlements.
- Polluted storm water run-off
- Industrial discharges

- Dumping into rivers and streams
- Proximity to waste sites
- Discharges from sewage treatment facilities

Input: Adequate

11. Sustainability/feasibility of water source

11.1 Sustainability/feasibility of water source

The groundwater potential in the region is generally poor, resulting in low borehole yields (±80% of all registered boreholes within BCM have yields below 2 l/s) and high salinity waters. The bulk of the East London population, which currently receives a formal water supply, is supplied from surface water supplies (some 95% of all households). However, there are a few of local groundwater supply schemes located along the coast to the west of East London.

Table H.18: Input for Sustainability of water source

%	Sustainability/ Feasibility of Source
10	Local Groundwater
	Rainwater
90	Local surface water
	Imported groundwater
	Greywater
	Storm water
	Imported surface water
	Brackish water
	wastewater
	Saltwater

12. Use

Table H.19: Profile of Urban Consumers within BCM

Consumer category	Greater East London	Greater King Williams Town	Mdantsane	Total	% of Total
Domestic	42 503	31 010	29 168	102 681	94.9
Business	3 508	1 045	272	4 825	4.5
Other	371	247	126	744	0.7
Total	46 382	32 302	29 566	108 250	100

From the Table H.19, it can be noted that:

- Some 94% of the consumer base is domestic, which accounts for some 77% of the recorded sales and 70% of the total amount billed; 92%
- Some 5% of the consumer base is business (industrial and commercial) and accounts for some 18% of the total recorded sales and 25% of the total amount billed;
- There is an extremely high dependency on the metered residential consumer (tariff sensitive) to fund operations i.e. 54.8% of the consumer base equates for about 70% of the amount billed (potential income);
- Business/industry consumption is relatively small and appears to have limited ability to fund operations above current levels; and
- Other consumers (e.g. schools) account for some 1% of the consumer base, 5% of the recorded sales and 5% of the total amount billed.

12.1 Domestic:

Domestic use of water use across EL is about 20kl/month per households. This is the equivalent of about 200l/person/day. Input: 151-200.

12.2 Industrial

From the WSDP table, for Greater East London industrial usage: 3508/46382*100 = 0.0756 which is 7.6%. Input: 9%-5%

12.3 Agricultural

There is not a lot of agricultural activity in the city of East London. Input: 1999-1700ℓ.c/d.

12.4 Maintenance of ecosystems:

From the State of Environment report (BCM, 2007) Input: 14-10%

13. Wastewater management

13.1 Effluent quantity

It is assumed that 40% of the 200l/person/day becomes wastewater. Input: 51-100ℓ.c/d

13.2 Effluent quality
- COD 75-150 (mg/l)
- P 11-15 (mg/l)
- Ammonia 21-150 (mg/l)
- COD 20-50 (mg/l)

13.3 River Health classification: information from the RHP (2005) Input: Good

14. Storm water management:

14.1 Effluent quantity: Dependant on LOS

14.2 Effluent quality: Dependant on LOS

15. Compatibility of water system with the surrounding environment

15.1 Proximity to solid waste dump or landfill site

The various waste streams described above are disposed of in a number of landfill sites, of which there are currently six operating in BCM: King William's Town, NU2 in Mdantsane, Second Creek, Ducats, Rieger and Gonubie. Most of the existing and closed landfill sites are the cause of significant land and water pollution in BCM. However, no water supply is located in proximity of water supply.

Table H.20: Compatibility of water supply with surrounding environment

%	Level of service	% located close to: dump/landfill
63	LOS1	0
	LOS2	0
	LOS3	0
10	LOS4	0
27	LOS5	0

16. Compatibility of sanitation systems with the surrounding environment

16.1 Located on flood prone area

No data available. Average result given

16.2 Steepness of slope

No data available. Average result given

16.3 Depth to groundwater table

No data available. Average result given

16.4 Soil permeability: medium permeability

No data available. Average result given

16.5 Ground stability

No data available. Average result given

17. Environmental stresses

17.1 % of polluted water sources. Input >50%

17.2 % of total area identified as severely water stressed. Input 21-30%

IV. Political support and stewardship

18. Governance

Qualitative assessments for all three variables were made based on review of the literature, a visit to East London, consultation with a BCM official (Sandile Booi- Manager of Water Services Authority) and personal observations.

18.1 Democracy and representation- Input: Very good

18.2 Measure of corruption

Extract from Sandile Booi interview: With regard to the level of corruption – "there is a long and accountable process involved with tenders etc, therefore there is limited room for corruption however it does occur. The municipality tries to counter this by making tenders an open process, advertising in newspapers. They use a scoring system for tenders and committees are used to select. The tender process is legislated therefore not a lot of corruption can occur". Input: Low

18.3 Defined roles and responsibilities

Input: Supporting policy and legislation, and good implementability

19. Compliance with policy and regulation

19.1 Compliance with government policies: Dependant on LOS

19.2 Compliance with MDGs: Dependant on LOS

20. Progress with meeting the MDG targets

Information from the UNDP (2005):

20.1 % with access to protected water. Input: 90-70%

20.2 % with access to adequate sanitation. Input: 90-70%

V. Institutional capacity

21. Institutional and technical capacity

21.1 Adoption of IWRM approach

Different sectors work together when forming reports such as the WSDP and IDP. Aside from that an IWRM approach is not being proactively pursued (Sandile Booi). Input: Planning.

21.2 No of water management institutions

There are two water management institutions i.e BCM and Amatola Water. Input 1-2

21.3 Adoption of alternative water supply technologies

Consultation with water managers within East London has shown that little to no alternative water supply technologies have been implemented by the water management authorities (Sandile Booi).

Although techniques such as rainwater harvesting may have been implemented privately, the high domestic water use also indicates that this has not been undertaken to any significant degree. Input: 0%.

21.4 Adoption of sustainable sanitation

The WSDP stated that alternative sanitation technology options have been considered including: VIP, Drying Pit and Urine Diversion. The final option(s) implemented will be determined based on the findings of pilot projects; taking financial, service requirements, environmental and social considerations into account. Low flow package type wastewater treatment works have also been considered to facilitate development where higher levels of service are to be provided, in areas where existing waste water infrastructure is at capacity. Input: 1-9%.

21.5 Corresponding education levels for staff

Input: 99-70%

21.6 Monitoring capability

General reporting is done regularly and competently by the municipality however sustainability and environmental performance does not seem to be monitored at all. Plus there is no dedicated monitoring team, so it is not done regularly. Input 6-4.

21.7 Reliability of service provision

Service provision is generally reliable with occasional service cuts occurring for maintenance procedures (Sandile Booi). Input 90-80%.

21.8 Failure in service delivery due to dependence on other sectors

Information found in the DMP stated that electricity blackouts affect various areas as a result of infrastructure failure and national load shedding. Sewerage failure occurs mainly as a result of power failure in the city, and in Duncan Village due to blockages. Solid waste failure occurs rarely as a result of vehicle breakdowns. Input: >6times/year.

H.2: East London full SI 2009 results

Components	Score	Indicators	Score	Variables	Score
1. Social security	2.43	1. Levels of Service (LOS)	4.35	1.1 Water supply	5.77
				1.2 Sanitation	3.70
				1.3 Drainage	4.10
				1.4 Waste collection	3.83
		2. Vulnerability to disasters	2.71	2.1 Susceptibility to natural disasters	1.40
				2.2 Risk Management and disaster mitigation	4.00
		3. Health	0.00	3.1 Under 5 mortality rate	0.00
				3.2 HIV/AIDS prevalence	0.00
		4. Education and awareness	2.67	4.1 % of people with secondary education	0.00
				4.2 Level of stakeholders consultation and public participation	4.00
				4.3 Level of dissemination	4.00
2. Economic	2.56	5. Capacity (to pay or access services)	1.50	5.1 Unemployment rate	3.00
				5.2 Income levels	0.00
		6. Cost Recovery	3.00	6.1 % users paying for water	4.00
				6.2 % of unaccounted for water (UFW)	2.00
		7. Investment levels	3.00	7.1 % budget increase for water supply	2.00
				7.2 % budget increase for sanitation	2.00
				7.3 Sources of investment	5.00

H.2: East London full SI 2009 results (cont.)

Components	Score	Indicators	Score	Variables	Score
3. Environmental performance	2.26	8. Fresh water Resources	3.00	8.1 Per capita water availability (l/capita/day)	2.00
				8.2 Water quality at source	4.00
		9.Sustainability/ Feasibility of water sources	3.00	9.1 Sustainability of source	4.10
				9.2 River Health Index	4.00
		10. Use (resource distribution per sector)	2.00	10.1 Domestic	5.00
				10.2 Industrial	1.00
				10.3 Agricultural and livestock	1.00
				10.4 Maintenance of ecosystems	1.00
		11. Wastewater management	3.50	11.1 Effluent quantity	3.00
4. Political support and international stewardship	4.17	12. Governance	4.33	12.1 Democracy and representation	4.00
				12.2 Measure of corruption	4.00
				12.3 Defined roles and responsibilities	5.00
		13. Progress with meeting the MDGs targets	4.00	13.1 % with access to protected water	4.00
				13.2 % with access to adequate sanitation	4.00
5. Institutional capacity and technological progress	2.60	14. Institutional capacity and technological progress	2.60	14.1 Adoption of IUWM approach	4.00
				14.2 Adoption of alternative water supply technologies	1.00
				14.3 Adoption of 'sustainable' sanitation	1.00
				14.4 Monitoring capability	3.00
				14.5 Reliability of service provision	4.00